

The logo consists of the letters 'd', 'c', 'e', 'e' in the first row and '2', '0', '1', '6' in the second row. Each character is rendered in a white, sans-serif font and is contained within a circular or semi-circular teal-colored shape. The background of the entire page is a complex, low-poly geometric pattern in various shades of teal and light blue.

d|c|e|e 2|0|1|6

DCEE 2016

5th International Workshop on
Design in Civil and Environmental Engineering
October 6-8th Sapienza University of Rome, ITALY

Program and Abstracts

Welcome address

In his 1969 book "The Sciences of the Artificial" (MIT Press), Herbert A. Simon, argues that design is the central activity that defines engineering and distinguishes it from the natural sciences. In fact, design is much more than engineering: it encompasses many different skills and disciplines.

In Civil and Environmental Engineering (CEE) in particular, design has typically been housed within each of the civil domains, shrouded by analysis, replaced by standards and building codes, and unable to cross the disciplinary boundaries as it was meant to do.

Yet, many of the greatest challenges that humanity will face in the 21st century will require civil and environmental engineers and architects to develop creative and innovative solutions that will radically alter our infrastructure and the built environment.

The DCEE series of workshops explore what it would mean for design to be a discipline within CEE, what it means for design to be a discipline in other areas of engineering, and the implication for interdisciplinary design in cooperation with other fields such as architecture, urban planning, industrial design, product design and more.

It is a great pleasure to welcome you to Rome for the 5th International Workshop on Design for Civil and Environmental Engineering where we will explore the nature of design in civil and environmental engineering and establish the foundation for civil design research.

The workshop scientific program is divided in 6 sessions on design methodology and education, and on the role of the interdisciplinarity in the design process, with 18 presentations and 2 plenary lectures.

The workshop includes two guided tours. The first tour is at the *Palazzo della Civiltà Italiana* known also as the *Colosseo Quadrato* (Square Colosseum), an icon of Modern Architecture, nowadays housing the luxury fashion label Fendi. The second tour will focus on ancient Rome, and on recent and extraordinary findings in the north-eastern area of the Palatine Hill archaeological site.

We hope you will enjoy your staying in Rome and we look forward to fruitful discussions during the meetings and the other activities.

The workshop chairs

Prof. Franco Bontempi, Sapienza University of Rome

Dr. Konstantinos Gkoumas, StroNGER srl

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Technical program

October 6th 2016 (Day I: Thursday) - Sala degli Affreschi del Chiostro

09.00-09.30 Registration

09.30-09.40 Opening Address (F. Bontempi)

09.40-09.50 Welcome Greetings from the Dean of the School of Engineering
(F. Vestroni,)

09.50-10.30 Keynote I: P. G. Malerba: Conceptual design: from abstract reasoning to consistent details

10.30-11.00 Coffee Break

11.00-12.10 Paper session I: Design Methodology: architectural and structural design Chair: **S-H Hsieh** (1h paper presentations + 10min discussions)

1. P. Trovalusci: The recovery of the 'ethic' of constructions: P. L. Nervi vs S. Musmeci, two structural conceptions compared

2. R. Kamiyama: Aesthetic Trends and Sustaining Process of Aesthetic Value of Japanese Temple Gardens

3. E. Mele, M. Fraldi, G. M. Montuori, G. Perrella: "Non-conventional" Structural Patterns for Tall Buildings: from Diagrid to Hexagrid and Beyond

12.10-13.20 Paper session II: Design Methodology: architectural and structural design Chair: **Y. Kubota** (1h paper presentations + 10min discussions)

1. Y. Mizuno, Y. Kubota: Structural Form of Bridges Reflecting the Construction Processes

2. I. Vassilopoulou, K. Seferoglou: Design of temporary deep foundation and monitoring for the erection of an arched bridge over an active landslide

3. T. Trombetti: Sandwich concrete walls: how a technology of the past can help obtaining hyper resistant seismic structures

13.20-14.20 Lunch break

14.20-15.30 Paper session III: Design Methodology: materials and technology
Chair: **E. Mele** (1h paper presentations + 10min discussions)

1. M. Antinori, M. Guidotti, G. Manzini, F. Scavazza: The design assisted by testing: a research project of a cold formed steel building system

2. G. M. Kim, H. K. Lee: Overview of strength aspects of carbon nanotube (CNT)-reinforced cementitious composites

3 C. Chiti: Thermal and sound performance of lightweight constructions

16.30-18.30 Guided Tour I: Palazzo della Civiltà Italiana – FENDI HQ

19.30- 21.00 Welcome cocktail: Cloister of the Engineering Faculty

End of Day I

October 7th 2016 (Day 2: Friday) - Sala degli Affreschi del Chiostro

09.30-10.40 Paper session IV: Interdisciplinary challenges in engineering design

Chair: **H. K. Lee** (1h paper presentations + 10min discussions)

1. S. Osaki, Y. Nakai: Design Philosophy and Methodology Required for the Survivors of Japan's 2011 Tsunami
2. K. Gkoumas, F. Petrini, S. Arangio, C. Crosti, F. Bontempi: Development of a piezoelectric energy harvesting sensor: from concept to reality
3. G. Galiano, A. Cutini: Social housing as a means of urban regeneration

10.40-11.20 Coffee break

11.20-12.30 Paper session V: Interdisciplinary challenges in engineering design

Chair: **L. B. Jensen** (1h paper presentations + 10min discussions)

1. F. Biondini, L. Capacci, A. Titi: Seismic Resilience of Aging Bridges and Evolving Road Networks
2. K. Espenhein, L. B. Jensen: Designing in the framework of sustainability certification systems – a survey of trends
3. F. Petrini, K. Gkoumas, F. Bontempi: Energy Harvesting from Flow-Induced vibrations: numerical analysis and experimental testing

12.30-13.30 Lunch break

13.30-14.10 Keynote 2: C. Gantes: Interaction between education, research and practice in structural steel design

14.10-15.20 Paper session VI: Design education in engineering design

Chair: **M-M Song** (1h paper presentations + 10min discussions)

1. M-D Chen, S-H Hsieh, M-M Song, S-Y Lai: Pedagogical Learning from a Future-Oriented Interdisciplinary Design Course
2. Y-H Tsai, C-Y Wei, J-Y Wang, M-H Li, Y-H Pan, I-F Chen, S-H Hsieh: Designing a MOOC for a capstone project in Civil Engineering
3. R. Panei, P. Trovalusci: Architectural design of recycling areas

15.20-15.30: M. L. Santarelli: The CISTeC (Research Center in Science and Technology for the Conservation of historical-architectural heritage) and the "Excavating in Ancient Rome - Valley of the Colosseum and Palatine Hill" crowdfunding project

16.00-18.00 Guided Tour 2: Recent and extraordinary findings in the north-eastern area of the Palatine Hill archaeological site (overviewed by the head-archeologist Prof. Clementina Panella – max capacity: 20)

19.30-21.00 Workshop Dinner: Suburra 1930 restaurant, Piazza della Suburra 13, Metro Cavour

End of Day 2

October 8th 2016 (Day 3: Saturday) – Mini workshop: Innovative aspects of engineering and architectural design and education
DISG Department meeting room

09.30-10.00 Kick-off presentation: Construction process for the metaphysics of architecture (A. Trento)

10.00-11.30 Innovative(?) aspects of engineering and architectural design/education
(A. Fioravanti, F. Bontempi, K. Gkoumas, E. Mele, T. Trombetti - others to be confirmed)

11.30-12.00 Coffee break

12.00-13.00 Round table

13.00-13.30 Closing remarks (F. Bontempi and K. Gkoumas)

End of the workshop

Sessions and Abstracts

Paper session I: Design Methodology: architectural and structural design

Chair: **S-H Hsieh**

The recovery of the 'ethic' of construction: P. L. Nervi vs S. Musmeci, two structural conceptions compared

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Abstract: At present, exploiting the wide possibilities offered by new sophisticated software, the design of new structural forms finds a significant propulsion. This onward process puts in front of the crucial question: how to manage and control the consistent computational-technological heritage in order to dominate and make best use of it in agreement with the building practice? In the actual electronic context and in the visual communication era ('deconstructionism', 'non linearity', 'virtuality') is it possible that architecture preserves a *tectonic ethic*, aimed at realizing the unity of the Vitruvian triad without abandoning the communicative content of the realized work? This work tries to give an answer by comparing two paradigmatic figures of structural engineer-architect of 19th century, Pier Luigi Nervi and Sergio Musmeci, who used the language of rational mechanics and structural engineering in very different ways, both with a careful look at the needs of Image communication. On one hand Nervi (or the *constructive dimension*), who finalized his work to credit the role played by the structural-constructive component ('*firmitas*'/'*tectonics*') in the realized architectures by resizing the role of the quantitative aspects of structural mechanics, often conceived as a limit for the creative invention. On the other hand Musmeci (or the *mathematical dimension*), who aimed at recognize and valorise the, less evident, links between architecture, mathematics and scientific language tout-court.

To the tectonic ethics of Nervi, of exquisitely hand-crafted base related to the most proper qualitative aspects of the art of building, the mathematic conceptions of Musmeci is contraposed. This latter, moving from the debate on the catenary and the studies of the seventeenth and eighteenth on equilibrium of elastic membranes and shells, passing through the analysis of minimal surfaces, has introduced the necessity to extensively resort to the mechanic-mathematic background in architecture, pioneering the design of structures resistant by form, now supported by the use of structural optimization algorithms.

The possibilities offered by numerical calculus increase now the capability of design of new structural shapes, even in a direction which goes beyond the requirements of optimal structural performance, far from the teaching of Musmeci itself. This mostly because of the diffusion of algorithms for generation of purely geometric shapes. The creation of innovative forms, which in the past was often entrusted to the technological invention ('technics'), with the result of a substantial correspondence between conception and execution, today seems entrusted to the mathematical-numerical instrumentation provided by software ('technique'). Creativity is instrumentally more free, structural analysis codes allow to overcome the heavy computational cost lamented by Nervi, but the dichotomy between the designed and realized architecture is more and more accentuated. In particular, the progress in the innovative designed shapes is not accompanied by a real progress in building technologies, rather in most cases traditional technologies are employed with very expensive working charge. Besides the building difficulties, the proposed shapes rather than be innovative, paradoxically, often fall into a repetitive figurativeness.

With a view to regain the correspondence between new designed shapes and realized forms, the actuality of Nervi's teaching emerges today in all its evidence: "it needs to design the realization".

Aesthetic Trends and Sustaining Process of Aesthetic Value of Japanese Temple Gardens

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Abstract: Despite aesthetic preferences can be unpredictably changed with the time, place, and person, many of famous temple gardens remain to attract people for a long time. One of the possible reasons is that these gardens occasionally or gradually transformed the visual appearance and spatial composition by responding cultural and historical aesthetic trend in their formative periods. Consequently the aesthetic value are added and integrated by time. As a result, many of highly recognized gardens sustain variable, stable, or even universal aestheticity. These principles of sustained aesthetic value by gradual changes through a series of process are capable of being applied to the contemporary landscape planning and other planning disciplines. However, in previous studies, aesthetic value in a certain period of time is well known, the sequential process of sustaining aesthetic value is less mentioned. Therefore, this research focuses on the sustaining process of aesthetic value and discussed it by three phases: judgment, transformation, and sustainment phase. Judgment phase is to identify the aesthetic trend by historic and cultural background and philosophy of owners by reviewing literature and compare and contrast different temple gardens. Transformation phase is to identify how to transform aesthetic trend and value into spatial composition of garden and the surroundings by referring old records, maps, and drawings. Sustainment phase is to identify how aesthetic value is maintained, established, and enhanced by analyzing chronological changes. In this paper, case study of Ryoan-ji, which is one of the famous temple gardens in Kyoto, is introduced to explain the aesthetic trend and explore the sustaining process of aesthetic value.

“Non-conventional” Structural Patterns for Tall Buildings: from Diagrid to Hexagrid and Beyond

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Abstract: Structural configurations best addressing the traditional requirements of strength and stiffness for tall buildings are the ones employing the tube concept, whose efficiency, however, is strictly related to the involved shear-resisting mechanism. In this perspective DiaGrid (i.e. Diagonal Grid) structures show an extraordinary efficiency, related to the adopted geometrical pattern: thanks to the triangle tessellation of the façades, internal axial forces are largely prevalent in the structural members, thus shear lag effects and racking deformations are minimized.

However, alternative geometrical patterns are worth of consideration for their structural and aesthetical qualities. Natural patterns, i.e. geometrical patterns observable in nature, can be a fruitful and almost endless source of inspirations for efficient man-made structures, at all scale levels (from the very tiny - material design - to the biggest – tall buildings - embracing all intermediate steps).

On the basis of these brief notes, a wide research activity has been undertaken starting from the idea that natural structures, as well as cross-fertilization between science and engineering, can provide a radically new repertoire of architectural forms and structural systems for tall buildings.

In this paper, a first insight on “non-conventional” structural patterns, to be adopted in tube configurations for tall buildings, is provided. The idea is to investigate the mechanical properties of non conventional structural patterns, both regular (Hexagonal Grid, i.e. HexaGrid) and irregular (grid inspired by the Voronoi tessellation), in order to assess their applicability, and to compare their potential efficiency to the more popular diagrid system.

A general homogenization approach is established for dealing with any patterns, and a methodology for characterizing the structural patterns from the mechanical point of view is developed. The homogenization process, defined for regular patterns, is modified through a statistical approach and adapted for the analysis of irregular patterns, as the ones derived from Voronoi diagrams.

On the basis of a simple stiffness criterion, a preliminary design procedure is proposed and applied to a tall building case study.

Paper session II: Design Methodology: architectural and structural design

Chair: Y Kubota

Structural Form of Bridges Reflecting the Construction Processes

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Abstract: The structural form of a completed bridge is strongly affected by its structural form during construction. It follows that innovative construction processes sometimes produce innovative bridge designs. It is important to consider the construction process in conjunction with bridge design methods. This approach could be applied not only to new construction but also to replacements, reconstructions, or reinforcements. One of the authors has systematized the structural forms of bridges and clarified the principles underlying them. This paper aims to extend these principles to construction systems. In other words, changes in the structural systems of the construction processes and systematization of the relationship between a completed bridge and construction process in a design are illustrated. This systematization enables the application of a variety of conventional construction methods in a system. This would be helpful in developing new construction methods and designs for bridges.

Keywords: Systematization, Construction Process, Innovative Bridge Design

Design of temporary deep foundation and monitoring for the erection of an arched bridge over an active landslide

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Abstract: The Tsakona landslide (February 2003) is one of the largest landslides occurred in Greece with significant impact on the economic and social life of southern Peloponnese. It caused large soil mass movement within a range of hundreds of meters. For the rehabilitation of the Highway it was decided to construct an arched steel bridge over the sliding slope. 14 twin temporary towers were required for the erection of the arch and the deck. Their foundation consisted of piles and pile-caps, built in the old active landslide where the evolving movements were observed.

The whole project was fully monitored with a network of geotechnical instrumentation (optical targets, inclinometers, piezometers) and an automated system (inclinometers, piezometers, rain gauge), continuously recording, monitoring and updating a database, which was simultaneously linked with a software program. It was providing the basic parameters of the slide movements in order to assess the risk associated with the slide, facilitate the design of the deep foundation, and inform the assembling engineers of any excess movements of the towers' foundation. Several two and three-dimensional finite element models were set up, and numerical analyses were conducted, in order to study the response of the towers' foundation due to the landslide movements and finalize their design.

In this work the monitoring system is described, emphasizing on the system design, the process of continuous recording and the evaluation of the measurements. The main assumptions of the deep temporary foundation design are underlined, incorporating the monitoring results and the profiles of the ground movement. The results of the geotechnical and structural analyses, which led to the final design of the towers' foundation, are also included. Key issues of the design were the depth of the piles in relation to the steep underlying bedrock, the estimation of the piles' bearing capacity under the assumption that the whole system was temporary and the cost optimization, which was always a requirement by the contractor.

Keywords: deep foundation of temporary works, monitoring of displacements, active landslide.

Sandwich concrete walls: how a technology of the past can help obtaining hyper resistant seismic structures

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Abstract: Seismic Engineering (based upon the fundamental concepts of “ductile design” e consequent “programmed damage” of building structures under sever shaking) basically dates back its origin at the end of 1950’s and beginning of the ‘60’s with the fundamental contributions of Newmark and Veletsos. The concepts introduced at that time, have then evolved more and more and reached the contemporary approaches which go under the name of Performance Based Design and of Direct Displacement Design, that have been successfully applied to frame building structures. The present paper introduces a building construction technology that allows to overcome the limitations imposed by the above mentioned approaches and is capable to bringing within economic and technology reach the realization of superior seismic performances under severe earthquake (such as absolute absence of damage in all building parts, both in structural and non structural components, and total guarantee of occupant survival). The proposed system (which has been fine tuned by a series of static and dynamic tests, as well as extensive analytical/numerical analysis) draws its superior performances not just from an innovative technology, but mainly from the re-discovery of an old structural system (bearing walls instead of frames), in this case realized using modern materials and technologies. This lead to a number of cultural and philosophical consideration upon the activity of the engineer: conceptual designer, of just developer of detailed analysis and simulations?

Paper session III: material and technology

Chair: **E. Mele**

**The design assisted by testing:
a research project of a cold formed steel building system**

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Abstract: The economic crisis of recent years and the increased competitiveness of the market provided the fertile environment for a new interest by COGI in the process of innovation and diversification of their product. COGI decided to expand its production with the development of a cold formed steel industrialized building system, named steelMAX®. The peculiarity of this product such as the light weight, durability, high efficiency, simplicity and rapidity of installation result in competitive structural systems. However, the design of this structural typology is fairly complex, so few years ago, COGI started a research project focusing on the development of steelMAX building system with the aim of providing simplified design rules. The study investigated the achievement of all the performance requirements related to the design of this technology such as the structural safety, the thermal and sound insulation and the fire resistance. Several full-scale tests were performed in order to evaluate the performances of the system. The experimental studies have been performed in collaboration with the University of Trento and other Laboratories.

Keywords: cold formed steel, thin-walled, light weight, building system.

Overview of strength aspects of carbon nanotube (CNT)-reinforced cementitious composites

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Abstract: Due to the outstanding mechanical, electrical and thermal properties of CNT [1], many studies have been attempted to develop a CNT-reinforced cementitious composite. It has been reported in the previous studies that the dispersion state of CNT in cementitious matrix and the bond strength between CNT and hydration products are major factors that affect the mechanical properties of CNT-reinforced cementitious composites [2]. In this paper, the mechanical properties of CNT-reinforced cementitious composite considering various CNT contents were reviewed. In addition, the effects of the dispersion technique of CNT in cementitious matrix and bonding characteristics between CNT and hydration products on the mechanical properties of the composites were discussed in detail. Specifically, the correlation between strength enhancement and dispersiveness of CNT will be analyzed.

Thermal and sound performance of lightweight constructions

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Abstract: A high-performance building envelope is synonymous with healthy living. Lightweight steel constructions as significant technological development to make buildings sure and more comfortable. Knauf presents the own analysis of thermal and acoustic behavior of drywall elements: analyzing the contribution of the metal profiles to the linear thermal bridge and soundproofing level. The range thickness of the metal stud analyzed (0,5÷2,5mm) could be used for load-bearing and non-load bearing elements: according with European directive 2010/31/UE-EPBD2 and UNI 11367 – UNI 11444.

Keywords: Drywall, Thermal bridge, Soundproofing, Metal profiles thickness.

Paper session IV: Interdisciplinary challenges in engineering design

Chair: **H. K. Lee**

Design Philosophy and Methodology Required for the Survivors of Japan's 2011 Tsunami

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Abstract: This paper discusses the philosophy and methodology of Civil Engineering Design upon a case study of a design project; small public space created to encourage and heal the survivors in the aftermath of the March 2011 Tsunami of Japan. Our team proposed creating bar/food stands where people can gather, relax, eat, drink and chat freely out of the shelters to cope with their severe loss in Otsuchi Iwate. They had suffered from two kinds of loss; the loss of bonds among people and with the land. The citizens not only lost their family and/or friends but were split off from their local communities. The citizens lost their hometown overnight. After weeks of preparation, a small square finally opened and recreated the scenes of citizens gathering and chatting right in the center of the town, which symbolically represented the recovery of the two bonds. An important role of Civil Engineering Design lays in a philosophy of enriching people's emotional QOL rather than designing shapes or colors. This case suggests a methodology to restore the bonds at an earlier stage of regeneration from disasters.

Keywords: Design Philosophy, Design Methodology, Regeneration from Disaster, Design Project

Development of a piezoelectric energy harvesting sensor: from concept to reality

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Abstract: This study focuses on the development and integrated design over a 24-month period of a high efficiency energy-harvesting (EH) temperature sensor, based on piezoelectric materials, with applications for the sustainability of smart buildings, structures and infrastructures. The development of the device was supported by ESA (the European Space Agency) under a program for the space technology transfer, and was concluded in June 2016.

The EH sensor, harvests the airflow inside Heating, Ventilation and Air Conditioning (HVAC) systems, using a piezoelectric component and an appropriate customizable aerodynamic appendix or fin that takes advantage of specific air flow effects (principally Vortex Shedding and Galloping), and is implemented for optimizing the energy consumption in buildings.

The project was divided in several work-packages (some running in parallel) that cover different aspects of the device development. Some of them focus on engineering aspects (starting from the numerical modeling, prototyping, and concluding with experimental testing). Other aspects focus on the commercialization of the sensor (including the development of a business plan, the intellectual property rights, the final design and the go-to-market actions).

Considering the multidisciplinary character of the project (which raises from the fact that it involves knowledge from fields such as wind engineering, electrical engineering, industrial design, entrepreneurship), this study will try to provide an insight on the complex design issues that arise when such complex, sometimes conflicting and overlapping aspects have to be managed within strict deadlines. In doing so, the most important design and development aspects (e.g. design choices, outsourcing issues, and parts optimization) will be critically reviewed.

Keywords: building automation, energy harvesting, sensor, project management.

Social housing as a means of urban regeneration

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Abstract: In recent years the pressing global economic crisis has determined a profound change in the social structure, bringing to light new situations of poverty that are increasing the impelling demand for social housing. The production of housing, necessary to help the most vulnerable social groups including the new poor, is not easy to realize in the light of the so-called "crisis of public resources."

Another very topical issue is the question of the "land use and soil sealing", that is the awareness of having to appease the intensive use of this limited resource and not reproducible. From these considerations is the need to operate through the regeneration rather than with the new building. To implement the land use control is necessary to go through the urban regeneration intended as transformation, re-use and upgrading of the housing stock unused or underused.

The old towns that have suffered depopulation and now take on the configuration of ghost places, are fascinating, rich in history and traditions, but they need regeneration to avoid becoming a museum but an active part of the city.

This study aims to propose a regeneration strategy of a minor historic center taking advantage of the relocation into it of commercial and reception activities that encourage new residential insertion and revitalize the agglomeration, a share of the buildings recovered will go destined to social housing.

The integration between services and residences is essential to get a good balance, in order to avoid the mistakes made in the past, especially when they were built entire neighborhoods destined exclusively residential building (dormitory quarters) in particular those intended for social housing who begat situations of degradation and difficult urban management.

Specifically, the project proposal, which requires a careful analysis of the sites, provides conservative actions directed to the protection, recovery, exploitation and safety of the ancient artifacts.

Particular attention should be paid to the functional recovery of the areas through the construction of social housing and a "Albergo Diffuso", with a network of services and infrastructure that allows full access to the village like the rest of the urbanized area.

Keywords: Social housing, regeneration, historic center.

Paper session V: Interdisciplinary challenges in engineering design

Chair: **L. B. Jensen**

Seismic Resilience of Aging Bridges and Evolving Road Networks

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Abstract: Resilience of bridges and infrastructure networks is generally investigated considering damage and disruption caused by sudden extreme events, such as earthquakes. However, damage could also arise continuously in time due to aging and structural deterioration, which can reduce over time the bridge structural performance and network functionality and, consequently, the system resilience. Therefore, for critical infrastructures exposed to seismic and environmental hazards, resilience depends on the time of occurrence of the seismic event [1]. The role of the detrimental effects of aging and deterioration may also change over time in consequence of the spatial evolution of the infrastructure network. This paper investigates the seismic resilience of aging infrastructures and presents a probabilistic approach to life-cycle seismic assessment of concrete bridges exposed to corrosion and resilience analysis of evolving road networks under prescribed earthquake scenario [2-4]. The seismic demand is evaluated for each bridge in the network based on a ground motion prediction equation in terms of earthquake magnitude and epicentral distance. The corresponding levels of seismic damage are derived from the bridge time-variant fragilities and related to vehicle restrictions and traffic limitations. Finally, a traffic analysis of the road network is carried out to compute both the time-variant system functionality and life-cycle seismic resilience under prescribed post-event recovery processes considering the evolution over time of the road network.

Designing in the framework of sustainability certification systems – a survey of trends

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Abstract: Increasing awareness of our impact on the world is more than ever before creating a need to design buildings using a documented and certifiable sustainable approach. However, using building sustainability assessment tools, such as DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen), involves comprehensive, complex and time-consuming activity during a design process. This has led to numerous attempts to optimise the design process from a management perspective or by employing a multi-criteria decision-making approach to the use of sustainability tools.

This study takes a holistic qualitative approach with the aim of finding key areas that need special focus during a design process, if a high level of sustainability is to be achieved. The method used in the present study was to gain information through interviews with DGNB auditors – professionals who have had responsibility for the full sustainability certification of a building and have performed as lead architects in the design process of that building. The interviewees were asked which areas they found most or least important during the design of a building, ranging from the client brief to the final design of the building, with regard to the framework of the sustainability certification system. The results from the interviews were analysed using Grounded Theory, a systematic methodology used in the social sciences.

The research showed that, when designing for a high level of sustainability, it is critical to address certain elements. The client brief must define a healthy framework, in terms of both economics and process, combined with linking elements that will ensure that specific goals are met. DGNB consists of around 40 criteria and those that are weighted most in percentage terms, such as LCC and LCA criteria, need to be addressed through an iterative process, due to their size and implications for other criteria. Architectural quality was highly prized by both architects and engineers when interviewed, but architectural quality has a blurred and undefined position in the DGNB criteria.

The study showed that the experienced designers interviewed found it paramount for the project that all stakeholders take a highly integrated holistic approach if decent architecture, good collaboration and well-performing buildings are to be achieved using DGNB.

Energy Harvesting from Flow-Induced vibrations: numerical analysis and experimental testing

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Abstract: PiezoTSensor is a self-powered device for data monitoring and transmission inside HVAC (Heating, Ventilation and Air Conditioning) systems in operating conditions. The acquired data are transmitted inside a wireless network (not part of the product), with which PiezoTSensor is integrated, for optimizing the energy consumption of HVAC systems in the view of the new trend in Civil Engineering of pursuing the building automation.

PiezoTSensor has been developed during last two years with a set of activities ranging from the analytical and numerical modelling of its aerodynamic behaviour to the design of the electrical components for harvesting energy and experimental testing in wind tunnel with evaluation of both its mechanical and electrical performances.

The paper gives a paramount of the features of the device with particular focus on its experimental aero-electro-mechanical behaviour. Different shapes have been tested in the wind tunnel, by including or not the circuit for energy extraction, the procedure for the design of the experimental tests, such as the comparison of the tests results with the results provided by predictive numerical models are described. Discussion on EH-induced damping is provided.

Keywords: building automation, energy harvesting, aerodynamic, wind tunnel.

Paper session VI: Design education in engineering design

Chair: **M-M Song**

Pedagogical Learning from a Future-Oriented Interdisciplinary Design Course

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Abstract: This paper analyzes students' experiences in an interdisciplinary, problem-based design course that aimed to enhance students' capacities in interdisciplinary teamwork, collaboration, problem solving, futures thinking, innovative design and emerging technology. Students mainly from three different engineering programs at National Taiwan University—civil engineering, building & planning, and mechanical engineering—were given the choice to take on the role of one of the three professionals: architects and planners, civil engineers or mechanical engineers in this course. They were then grouped into interdisciplinary teams and given the assignment to revitalize and reuse one apartment building in an old neighborhood that had been designated for urban renewal in the near future. Using the real world issue, the course is devised to train students in solving real world problems and understanding real world communities. Applying futures thinking in design processes adds an extra layer to help students foresee the needs of future society and anticipate future problems, which are often ill-structured, ambiguous, and with multiple open-ended answers. In this paper, the curricular and pedagogical designs of this course are described and feedbacks from students are analyzed and presented, with the intention to help teachers develop better interdisciplinary design courses.

Keyword: problem-based learning, interdisciplinary design, futures thinking, learning style, engineering education.

Designing a MOOC for a capstone project in Civil Engineering

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Abstract: Massive open online courses (MOOCs) have become a worldwide trend for self-paced learning. Through MOOCs, students are able to learn the latest knowledge from top educators all over the world. A capstone project is designed for students to integrate the knowledge and skills taught in previous courses and is therefore an important practice for civil engineering students. However, there are some issues to be addressed when a capstone project course is offered on a MOOC platform. In this study, three issues are discussed. First of all, running a capstone project on a MOOC platform is not as realistic as running it in a classroom. Second, monitoring progress of massive number of students in MOOCs is an issue. Third, the limited interactions in a MOOC platform may decrease students' participation which is a key factor for the course success. To address these issues, some strategies are employed by the authors in the course designs of a MOOC course for a Civil Engineering capstone project. It is hoped that the experiences shared in this paper can benefit other educators who would like to design similar capstone project MOOCs.

Keywords: MOOCs, Online Course, Capstone Project, Project-based Learning, Course Design, Engineering Design, Engineering Education.

Architectural design of recycling areas

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Abstract: As a part of the rugged path towards improving the quality of life of urban centers, activities related to waste reduction are included. This this objective can be achieved by separating, collecting and reusing assets. Then, the realization of dedicated equipments and the development of a civic oriented sensibility are needed to promote the cultural conditions for the formation of a civilization founded on the principle of saving Reuse, also of energy sources.

The Faculty of Architecture of the University of Rome, in agreement with AMA'Roma, the municipal company of Urban Hygiene, addressed these topics within a specific Degree Atelier: ECOLOGICAL ISLANDS AND REUSE CENTERS - SUSTAINABLE DESIGN. The *Ecological Islands* are open to citizens equipment for temporary storage of non-organic waste, organized in different manner, to be subsequently undertaken for recycling activities. The *Reuse Centres* are spaces, available to all citizens, which integrates the function of the Ecological Islands by promoting the reuse of what is still useful and in good condition. In this way it is possible to counter and overcome the throwaway culture, supporting the dissemination of a culture of reuse of assets based on the principles of environmental protection and social solidarity.

The national legislation on waste acquired in 1997, with the so-called Ronchi decree (Legislative Decree No. 22/97), the European directives regarding the separate collection of waste. Since that time even in Italy it was necessary to organize the collection of waste in order to manage separately the different types to be recycled. The idea of Ecological Island born in those years and developed at the Municipal Urban Hygiene Company of Rome (AMA).

Today the reduction of waste production is the goal to be reached, also sanctioned by a resolution of the City Council of Rome. Assets addressed to the Ecological Island must be intercepted before they become waste and disposed of for reuse. To do this it is necessary to implement the system of Ecological Islands by aggregating structures used for a 'new' function; that is designing places where it is possible to store the objects and, as a result of necessary maintenance activity, addressing them to a 'new' life.



The main goal is therefore the formation of a double awareness of students (and future architects citizens): the rediscovery of a 'social role' of architecture, capable of improving the quality of life and at the same time the acquisition of a design approach oriented to work feasibility.

In the Degree Atelier projects on areas included in the development of the Hygiene Company's Business Plan are investigated, in such a way to develop feasibility studies starting from the choice of actual locations of the Plan. In this regard, a group of qualified professionals of the Company, interacts with undergraduate students by providing support and actively participating, even with ex-cathedra lessons as well as with regular reviews of projects. The contents range from photovoltaics to bioclimatic greenhouses, structures in natural materials (wood, bamboo, straw bales, etc.). The projects draw inspiration and encouragement from the environmental sustainability, the fascination linked to the recovery of discarded values, creating evocative shapes of high symbolic content; but never overlook or overshadow the actual feasibility of the same projects.

