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Sustainability & Resilience

SBE MALTA

International Conference 2019

Edited by Ruben Paul Borg & Cyril Spiteri Staines

SBE 19 Malta

Sustainability & Resilience

International Conference

21st and 22nd November 2019

SBE Malta
Sustainable Built Environment

SBE19 Malta

Sustainability & Resilience

Editors

Ruben Paul Borg
Cyril Spiteri Staines

International Conference

21st - 22nd November 2019

Sustainable Built Environment Malta

SBE Malta (Sustainable Built Environment Malta) is an organisation committed to Sustainable Development, education and research in green buildings and sustainable built environment. SBE Malta acts as the National Chapter of iiSBE, the International Initiative for a Sustainable Built Environment (www.iisbe.org). SBE Malta was set up in 2012 and registered as a voluntary organisation with the Commissioner for Voluntary Organisations in Malta. It is also registered as a legal entity with the Government of Malta. The primary objective of SBE Malta is the advancement of environmental protection and improvement by promoting Principles of Sustainable Development and Sustainability in the Built Environment. SBE Malta was set up as the Green Building and Sustainable Built Environment organisation in Malta, to establish relationships with professionals, public and private organisations at the local and the international level; to participate in international organisations; to promote the advancement of education; to conduct and promote research (www.sbemalta.com).

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Introduction
Sustainability and Resilience in the Built Environment

Ruben Paul Borg

President SBE Malta, Faculty for the Built Environment - University of Malta

Sustainability originates from the Latin; *Sustinere*, to hold, maintain support and endure. Resilience also originates form the Latin; *Resilire*, rebounding and bouncing back. (Liotta et al, 2010; Alexander, 2013).

The concept of sustainable development emerged as an important political vision and rose to prominence in the late 1980s. In 1987 the World Commission on Environment and Development referred to Sustainable Development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Bruntland Commission, WCES 1987). In this period, the construction industry began to generate the first sustainable building assessment systems addressing environmental, economic and social aspects for buildings through their life cycles.

Resilience is the ability to withstand and recover rapidly from disruptive events and has been considered to directly depend on the ability of the built environment to maintain and support the functions upon which modern society relies. Resilience is usually related to the occurrence of extreme events and disasters during the life cycle of structures and infrastructures. In the last decade it has been used to minimize specifically direct and indirect losses from hazards through enhanced resistance and robustness to extreme events, as well as more effective recovery strategies (Bocchini et al, 2014).

Therefore, in general sustainability is usually defined through the triple bottom line of environmental, social and economic system considerations, while resilience is usually viewed as the ability of a system to be prepared to absorb impacts and recover and adapt following persistent stress or a disruptive event.

Resilience is a property of a complex system and may indeed be counter to sustainability goals: for instance, efficiency reduces diversity and redundancy and yet, both of these, are key features of resilience. High-density urban areas are considered to promote more efficient energy distribution, communications and waste management but are more vulnerable to extreme actions such as flooding because they are less diverse and have less redundancies (Elmqvist, 2017). The differences and synergies between sustainability and resilience need to be appreciated first, for these concepts to be then applied in policy and practice.

A difference reported between sustainability and resilience, is referred to as the temporal scale of implementation, where sustainability efforts are often understood on longer time scales than resilience (Marchese et al, 2018). The primary objective of sustainability is to create desirable conditions for future generations (Meacham, 2016) and the effects of sustainability policies may have substantial effects on future conditions and may not directly influence present conditions. Resilience is in many situations understood to apply to more immediate temporal scales (Lew et al., 2016; Mejia-Giraldo et al., 2012) and policies that increase the resilience of a system will protect the system in the short term from potential disturbances. There is significant opportunity to develop sustainability practices that are more consistent with

resilience methods (Marchese et al, 2018). For example, sustainability can be considered as a critical function of a project, policy or system, which is to be maintained during and after a disturbance.

However, the Sendai Framework for Disaster Risk Reduction, encompasses 'the risk of small-scale and large-scale, frequent and infrequent, sudden and slow-onset disasters, caused by natural or manmade hazards as well as related environmental, technological and biological hazards and risks.' (United Nations, 2015). Furthermore, Building Back Better (BBB) is an approach proposed in post-disaster recovery that is intended to reduce vulnerability to future disasters and builds community resilience to address physical, social, environmental, and economic vulnerabilities and shocks (GFDRR, 2019). Therefore, Building Back Better supports sustainable practices.

Both resilience and sustainability analyses are of importance in the assessment of infrastructure and the impact on the community, and neither can be neglected (Bocchini et al, 2014). Sustainability and Resilience approaches attempt to optimize a system, such as a civil infrastructure system, with respect to structural design, material used, maintenance plans, management strategies, and impacts on society. However, researchers and practitioners focusing on either sustainability or resilience usually operate without mutual consideration leading to severe inefficiency. It is suggested that resilience and sustainability are complementary and should be used in an integrated perspective through the well-established framework of risk assessment (Bocchini et al, 2014). The impact of the infrastructure and its service states on society in normal operational conditions - assessed by sustainability analysis - and after exceptional events - assessed by resilience analysis - should be weighted by the associated probabilities of occurrence and combined in a global impact assessment (Bocchini et al, 2014).

It is reported that there is a lack of an integrated framework that combines both sustainability and resilience indicators for the assessment of energy technologies. The integration of sustainability and resilience indicators is required in an overall assessment framework for low-carbon energy technologies (Grafakos et al, 2018). High performance building design presents demands for greater resilience, which can be achieved at a minimum environmental cost. The integration of sustainability and resilience and the synergies or differences between the two is reported as a persistent knowledge gap (Phillips, 2017). In this regard quantitative modelling and hazard resistance are proposed within life cycle assessment of strategies to produce resilient and sustainable building designs. It is also important to note that materials science has an important role in enabling informed decisions for resilience and identify knowledge gaps, such as the service life of the materials designed for new construction or system repair (Watson et al, 2018).

Climate change presents challenges for future-proof and climate resilient buildings and infrastructure. Green Buildings address Climate Change primarily through a reduction in greenhouse gas emissions. However, greenhouse gas reductions are considered as climate change mitigation. The US Green Building Council (US GBC) Leadership in Energy and Environmental Design (LEED) allocates more than 25% of available points for reducing greenhouse gas emissions associated with building systems transportation, water, waste and construction materials (US Green Building Council, 2008). Both mitigation and adaptation strategies are however required in Green Buildings to achieve a built environment which is responsive and resilient to future climate extremes (Larsen et al., 2011). Climate related vulnerabilities are identified, and design, construction and operation strategies are defined for

increasing resilience and to facilitate climate adaptation (Larsen et al, 2011). The impacts of climate change at different scales from regional scale to building scale are addressed with respect to a range of predicted future characteristics in different categories and probable impacts. This is intended to define modified performance goals at neighbourhood and building level, to increase resilience and adaptive capacity. Synergies between green building and resilience are identified: addressing the implications of climate change for green building and identifying opportunities for resilience through the design, construction, and operation of buildings and communities; assessing how individual LEED credits support regional adaptation needs, such as enhanced water conservation in arid climates and water-sensitive regions; analysing how consideration of climate resilience in buildings can increase the likelihood of achieving performance goals throughout the lifetime of a project (Larsen et al, 2011).

SBE Malta (Sustainable Built Environment Malta) was founded as the Green Building and Sustainable Built Environment organisation in Malta, as the National Chapter of iiSBE (International Initiative for a Sustainable Built Environment). The organisation is committed to Sustainable Development, education and research in green buildings and sustainability in the built environment. SBE Malta organised the SBE 16 Malta Conference (Europe and the Mediterranean: Towards a Sustainable Built Environment) and the SBE 19 Malta Conference (Sustainability and Resilience), as part of the World SBE 19 Series addressing key areas promoting sustainable development and resilience in the built environment: resource efficiency, waste management, materials and structural engineering, smart systems, strategies for cultural heritage and building refurbishment, strategic planning and urban design, transport infrastructure, energy efficiency and renewable energy, disaster resilience, economic, social and education aspects. The objective of SBE 19 Malta is to create a forum for experts to address the knowledge gaps which exist in sustainability and resilience in the built environment and to promote the development of sustainable and resilient design.

Implementation of Sustainability and Resilience in the Built Environment can be achieved in policy and also in practice through practical applications in the built environment, if the fundamental differences and synergies between the two are well appreciated by the academic community and effectively communicated to policy makers.

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SBE MALTA

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Sustainability and Resilience

RESHEALIENCE Rethinking coastal defence and green Energy Service infrastructures through enHancEd durAbility high-performance fiber reinforced cement-based materials.

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Recently, in the framework of H2020, the European Commission has funded the project ReSHEALience, whose main goal is to develop an Ultra High Durability Concrete (UHDC) and a Durability Assessment-based Design (DAD) methodology for structures, to improve durability and predict their long-term performance under Extremely Aggressive Exposures. The improvement will be supported upgrading Ultra High Performance Fiber Reinforced Concrete with new functionalities. Focus will be on marine structures and infrastructures for geothermal/biomass energy plants, whose severe conditions challenge the performance, lead to quick deterioration and shorten the lifespan, resulting in billions Euro spent each year in repairs. The project will tailor the mix composition of UHDC and upgrade experimental methods to validate its durability properties of UHDCs in service conditions, and develop a theoretical model to evaluate ageing and degradation of UHDC structures, extending the modelling to predict the lifespan. New design concepts will be proposed for the use of UHDC, and validated through long-term monitoring in six full-scale proofs-of concept, selected as representative of cutting edge economy sectors, such as green energy production, blue growth and conservation of r/c architectural heritage. The project, coordinated by Politecnico di Milano, gathers 14 partners from 8 different countries (Italy, Spain, Estonia, Germany, Greece, Ireland, Israel, Malta), including 6 acedemic/research institutions and 8 industrial partners, covering the whole value chain from producers of concrete constituents to construction companies to stake-holders and end-users in the field of green energy production and distribution. The paper will present the main concept and activities of the project.

Creating Resilient And Regenerative Cities – A Framework For Engaging With Urban Change

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Cities of the world are experiencing multiple and unprecedented crises and face an ever more uncertain future. Within this shifting environment we need to consider our current approaches to city planning as these are inadequate and ineffective in dealing with many of the challenges. In many cases they exacerbate the problems, as while improving the perceived quality of life for a few, the systemic effects are largely destructive. There is a growing realisation that these outdated approaches are based on a worldview that cannot deal with the complexity of living and evolving systems, resulting in flawed paradigms of practice. Alternative paradigms are presented by the discourses of resilience and regenerative development and design. Drawing on the theoretical constructs of complexity thinking, resilience thinking and whole systems thinking, a set of planning & design directives and spatial determinants of urban resilience comes together in a proposed framework for building adaptive capacity and healthy urban systems and enable urban transformation and regeneration.

Strategies for the Built Environment under Climate Change

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Recent scientific findings on climate change impacts are presented with regards the Built Environment. In addition, broad strategies that urban regions may adopt to deal with issues of adaptation and mitigation to Climate Change are also presented.

Rethinking construction knowledge and skills to build disaster resilience

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The past decade has seen a concentration of disaster events causing major social, economic and financial impacts. In order to tackle these increasing losses, the Sendai framework for disaster risk reduction 2015–2030, endorsed by 187 UN states in 2015, promotes disaster risk reduction practices that are multi-hazard and multisectoral, inclusive and accessible in order to be efficient and effective. The framework also identifies: "a need for the private sector to work more closely with other stakeholders and to create opportunities for collaboration, and for businesses to integrate disaster risk into their management practices"; and, "a need to promote the incorporation of disaster risk knowledge, including disaster prevention, mitigation, preparedness, response, recovery and rehabilitation, in formal and professional education and training". 2015 also saw the convergence of three global policy frameworks: the Sendai Framework for Disaster Risk Reduction 2015 - 30 (March 2015), the Sustainable Development Goals (September 2015; SDGs) and the Climate Change Agreement (December 2015: COP21). This represents an opportunity to emphasise cross-cutting themes, including the importance of research and education across the different global policy agendas in disaster risk reduction, sustainable development and climate-change mitigation and adaptation, and in doing so, to support evidence-based decision-making. The economic scale, size and impact of the built environment are significant. It is one of the largest sectors of the economy, comprises many businesses, and is a major employer. As a major consumer of services and intermediate products such as raw materials, chemicals or electrical equipment, construction impacts many other economic sectors. In recognition of the built environment's importance to a society, there have been growing calls for greater engagement of the construction industry in disaster resilience building efforts. Many studies have indicated a need for greater integration of disaster resilience concepts into the education of construction professionals. This paper is an account of a study to identify gaps in the knowledgebase of construction professionals that are undermining their ability to contribute to the development of a more disaster resilient society and preventing the mainstreaming of disaster resilience within the construction process. This study was part of an EU funded research project that is seeking to develop innovative and timely professional education that will update the knowledge and skills of construction professionals in the industry, and enable them to contribute more effectively to disaster resilience building efforts. The research involved a detailed study to capture labour market requirements for disaster resilience, and its interface with the construction industry and its professionals. The initial investigation aimed at capturing current and emerging skills for built environment professionals that could contribute to enhancing societal resilience to disasters across the property cycle (strategic definition, preparation and brief, concept design, developed

design, technical design, construction, handover and closeout, and in use), the needs of key stakeholders (local and national government, the community, NGOs, INGOs and other international agencies, academia and research organisations, and the private sector) involved in disaster resilience, and management and across five dimensions of resilience (social, economic, institutional, environmental, technological). This analytical framework was developed through an extensive consultation process with project partners. It was refined with the emerging literature findings and with the opinion of stakeholders who were interviewed to capture the labour market demands in construction industry to increase societal resilience to disasters. The CADRE study identified thirteen key knowledge gaps among construction professionals: Governance, legal frameworks and compliance; Sustainability and resilience; Business continuity management; Ethics and human rights; Disaster response; Innovative financing mechanisms; Contracts and procurement; Resilience technologies, engineering and infrastructure; Multi-stakeholder approach, inclusion and empowerment; Knowledge management; Social and cultural awareness; Post disaster project management; and, Multi-hazard risk assessment. Unprecedented urbanisation, changing demographics and changes to our climate are some of the trends that are driving disaster risk and reshaping the world in which we live and work. In order to address the complex challenges associated with resilience building, the role of the built environment professional will need to change. This signals the importance of a rethink around the types of knowledge that will be needed across the construction and property sector so that it can contribute towards the aims of the Sendai Framework for Disaster Risk Reduction 2015 - 30 and other global agreements on sustainability, climate and development.

BIM applications on building sustainability

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During the recent years there has been an increasing concern about the negative impacts buildings have on the environment. Due to the need of providing proper answers to the growing demand of sustainable buildings, several processes and technologies have been developed to support designer's decision making and to manage all the project data and complexity efficiently. Among those, stands out the Building Information Modelling (BIM), which is a working methodology that turns possible to manage all the project data and design in a virtual model, considering the entire life cycle of a building. By allowing multi-disciplinary information to be overlaid and grouped into a single model, BIM creates an excellent opportunity to incorporate sustainable principles throughout the different project stages. By analysing BIM software capabilities for building sustainability and published papers about the topic, this study investigates how the BIM method can enhance buildings sustainability. BIM practical applications are presented and listed, as well as the the discussion on the main benefits and challenges of using this method. Additionally, a successful project is analysed, where BIM played a key role to achieve designers' sustainable targets. BIM is still not oriented to support the design of sustainable buildings, but it has great potential to improve the actual context. This paper shows that it will become an essential tool for developing more sustainable and high-performance buildings, by effectively allowing to improve several aspects related to the main dimensions of sustainable construction.

Repair or Replace Structures?

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If a structure can be repaired, that is a sustainable solution. But structural health monitoring consultants are challenged with a question “to repair or to replace structures?” In this presentation it is elaborated how some of structures were convinced to repair using sustainability concepts, structural health monitoring and retrofitting techniques. As the first case study, a damaged bridge due to floods was considered and how it was adapted for the designing and retrofitting works. In order to determine the fitness of a damaged bridge for reuse, condition surveys are usually carried out. Using a validated numerical model of the damaged bridge (a finite element model, FEM), efficient designs are possible as such models can be loaded with past loading histories as well as future expected loadings and then the stresses and deflection can be obtained from the FEM. Then the fitness of the damaged bridge can be verified and elements which need to be replaced or retrofitted can be determined. The case study is about a 34 m long, 5.2 m wide, single spanned, double lattice girded, wrought iron railway bridge, located at Puttalam (Bridge No. 02 on the railway track between the Puttalam Cement Factory and Limestone Quarry, used for transporting limestone) which was built about 40 years ago and damaged and displaced from its abutments by floods. The bridge was thereafter placed on temporary timber abutments for several years. With the increase ent of cement production, the owners of the bridge wanted to use heavier locomotives on this railway track and also to increase the number of trips. Therefore, there was a need for an assessment of bridges on this track in order to determine whether the bridges can be used further or should be demolished and new bridges built in its place. In order to do the assessment, a condition survey was carried out on all the bridges on the track. One of the bridges was found weak as this had been damaged by floods. Then an analysis was done by modeling the bridge (FEM) by using general purpose SAP 2000 program and validating the FEM by using results of a field loading test (the bridge was temporarily erected on timber abutments for several years). Both static and dynamic loading tests were carried out using an M2 locomotive with 6 numbers of 13.16 ton axles for 5 different loading cases to measure the displacement, strain and acceleration at pre-determined (critical) members of the bridge. The future fatigue life of the bridge was estimated using the prescribed last method. The future life was found as 30 years with a factor of safety of 3. Further, using the validated model, the ability of the bridge for higher loading situations was confirmed. The cost, estimated for retrofitting work and constructing new reinforced concrete abutments was much less than that for constructing a new bridge. Therefore it was decided that rehabilitation of the bridge with necessary retrofitting work is more sustainable than demolishing it and constructing a new one. The bridge is now in use after being repaired, retrofitted and placed on new abutments. Few other case studies will be discussed to strength the concept and techniques.



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Materials in Civil Engineering

Survey of recycled aggregate concrete requirements in standards and guidelines of selected countries

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Construction and demolition waste (CDW) reducing is one of the world's and European priorities. Currently, half of the global total waste production occupies CDW, which generates about 3 billion tonnes of this waste per year. In order to create sustainable construction principles, recycled aggregate (RA), which is a significant component of the concrete composition, needs to be efficiently utilized to exploit its full potential. Production of a conventional concrete from recycled aggregates has long been the subject of scientific interest. Physical and mechanical properties of original concrete as well as characteristics of RA are significant factors influencing final recycled aggregate concrete (RAC), especially when used in structural concrete. Legislative documents, standards, and guidelines are formulated in different countries around the world, specifying the requirements for RAC properties, including the proportion of total aggregate replacement and other characteristics. Differences in RA and RAC requirements across documents vary greatly and are subject to continuous changes. The article aims to fill the literature gap by an actual and comprehensive compendium of standards and guidelines requirements across countries that are engaged in the issue of RAC production. The conclusion of the article deals with differences in particular countries and proposes further developments in the field of standardization of concrete recycling.

The Use of Landfilled Fly Ash in Polymer Cement Repair Mortar

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Pulverized fuel fly ash (PFA) produced as a by-product in the burning of coal in the Power Station in Malta was landfilled in disused quarries in Malta, with a significant environmental impact and health associated risks. The aim of this research was to analyse the properties of the fly ash and to attempt to utilize it as a partial cement replacement in polymer cement patch repair mortars, containing crystallization admixture for the rehabilitation of the reinforced concrete structures. On the basis of mechanical properties including the flexural and compressive strength at 60 days, it was concluded that 20% cement replacement resulted in the best results. The microstructure of the material was also assessed through scanning electron microscopy (SEM), to investigate the performance of the PFA particles incorporated in the polymer cement matrix. The utilization of PFA up to 30% as a replacement of the cement in mortar did not result in leachability of the mortar. The application of PFA effectively in polymer cement patch repair mortar also results in the exploitation of a landfilled waste, with significant environmental benefits.

Influence of fly ash and prefabricated plastic bubbles on the properties of expanded glass aggregates incorporating sustainable flowable lightweight concrete

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Transport, one of the most important socio-economic processes of urban life, has become locked into an unsustainable form. The dependence on carbon-based fuels makes the sector one of the highest CO_2 emitters. Despite this, transport has generally taken a low profile when it comes to emission reduction and could contribute more to climate change mitigation. This paper reports on a methodological framework that has been developed to formulate policies aimed towards the transition to low-carbon hence more sustainable mobility. The analysis builds on the theory of social practices as the underlying theoretical framework. Within this framework, transport can be explored as a socio-economic system embedded within the larger societal processes. Hence, from this perspective mobility becomes a consequence of the routines of everyday life. The framework also allows an investigation of how mobility practices are sequenced and interlocked with other social practices and how the sequence and spatial-temporal characteristics of these practices interact with and influence transport choices. This insight therefore means that a shift towards more sustainable mobility requires policy configurations that are aimed at reconfiguring both mobility and non-mobility practices of everyday life. When dealing with climate policies in transport increasing importance is being placed on the need to look at the longer-term future as many measures take time to be effective, and trend-breaking changes cannot be achieved within short-time frames. Backcasting scenario approaches are one type of empirical research technique which has been found to be promising when looking at challenging long-term futures. This paper demonstrates how a backcasting approach can help develop low-carbon transport futures. While taking Malta as a case study, it presents a mixed methodological approach which starts with the collection of information about the current trends and mobility practices. It then goes on to demonstrate how a participatory approach involving different stakeholders can be used to formulate visions of alternative, more sustainable futures and how these alternative scenarios can help in reducing CO_2 emissions from transport. Lastly, it provides a participatory framework which also relies on stakeholder interaction and social learning and through which policy pathways towards more sustainable mobility can be formulated.

Investigation of Alkali Activated Slag Reinforced with Wood Fibers

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Alkali-activated materials (AAMs) are well known alternatives to ordinary Portland cement (OPC) in order to limit CO_2 emissions and reduce the environmental impact. There are large amounts of industrial by-products, with varied aluminum and silicon compounds, which can be recycled in these materials. Binding materials based on AAMs, are much more ecologically friendly than Portland cement binders. The main properties of AAMs are similar to the properties of OPC, but mechanical or durability properties can even be improved. In spite of the encouraging properties of AAMs, these materials are classified as quasi-brittle materials and typically demonstrate poor flexural strength. Different types of reinforced fibers were used to increase the flexural strength of AAMs. The incorporation of steel, polypropylene, polyvinyl alcohol, sheet-like carbon and basalt fibers improved the mechanical and durability properties such as resistance against sulphates, acid resistance, water absorption and related properties. These fibers were incorportaed in the AAM, to strengthen the material. In this research ground granulated blast furnace slag is used as precursor and wood fiber are used for the reinforcement of AAMs. Wood fiber was included at 0%, 0.5%, 1.0%, 3.0% and 5.0 % by slag mass. The alkali activator considered was sodium hydroxide solution. According to literature, wood fibers improve the properties of alkali activated materials. The produced specimen were characterized by using scanning electron microscopy (SEM), X-ray diffraction analysis (XRD) and mechanical properties with reference to compressive and flexural strength. The results of the study showed that alkali-activated material produced from alkali-activated slag reinforced with wood fiber has a great potential as a construction material.

Minimization of carbon dioxide footprint of the next generation of infrastructure through optimized concrete mixture designs

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This paper addresses the long-term environmental advantage of the implementation of optimized blended cement in concrete mixtures for future generation of infrastructures. The current design trend of concrete mixtures is to lengthen the service life, reduce carbon dioxide emissions while ensure the sustainability in hazardous exposure conditions of structures. Concrete carbon dioxide footprint was developed for both Portland cement and other supplementary cementitious materials. Selected performance based concrete mixtures with design life from 75 to 100 years in the project of Bridges on Interstate 99 in central Pennsylvania were employed in the analysis. They were comparatively evaluated under the scheme of sustainable development of building materials via sample examples. Optimized concrete mixtures were elected with respect to their engineering performance characteristics, level of carbon dioxide discharge and total life cycle costs.

Effect of hight frequency activation on ultra high-performance concrete properties

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In this research fresh mixture of ultra-high performance concrete (UHPC) was affected by high frequency activation. High frequency activation has positive effect on dispersing conglomerated particles of Portland cement, silica fume and glass powder. Thus, positive effect in hydration process, flowability and compressive strength could be expected. In the research, effect of high frequency activation was investigated by semi-adiabatic calorimetric, density, flowability and compressive test methods. Proposed method allows to make more workable mixture with enhanced mechanical properties.

Behavior of FRP reinforced concrete beams made with recycled concrete aggregates

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This study presents a comparative experimental analysis between concrete beams made with 100% of recycled concrete aggregate (RCA) and reinforced with either steel or basalt fiber reinforced plastic (BFRP) bars. The parameter investigated in this study included the type of reinforcement (Steel and BFRP bars). Two large-scale beams were flexural tested until failure. The test results showed an excessive ultimate deflection at failure for the beam reinforced with BFRP bars compared with the one reinforced with conventional steel bars. In addition, test results showed that the use of RCA has no remarkable effect on the flexural capacity of RC beams.

Improving aggregates' quality: A sustainable resource management practice

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To achieve an environmentally friendly construction, the key factor is to reduce the waste generated. Regarding aggregates for infrastructure, design standards place a high value on quality aggregates. Complex morphology, test and production methods influence aggregates properties, thus resulting in varying performance characteristics. In this paper, flaky characteristics, water absorption, particle density, and resistance to fragmentation and wear are determined on four different aggregates (natural, crushed, tunnel and excavated materials). An attempt is made based on percentile mass-mix concentration (25%, 50%, and 75%) as premix to enhance aggregates with low properties. Performance of blended aggregates (i.e., a mixture of two or more) has been compared to aggregates with the same lithology characteristics under all test regimes (Los Angeles, flakiness index, water absorption, particle density, and micro-Deval tests) based on European Standards (EN). Test results demonstrate, that aggregates with varying and low measured properties can be partially surrogated into aggregates that perform well in the same test to form a blended mixture and re-tested, since all mixtures generated in this test met limit requirements. This method may reduce the cost and potential disposal of aggregates with lower physical and mechanical properties.

High performance cement composite matrix: selection of raw materials and design of mixture composition

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The application of High Performance Cement Composite (HPCC) for wall-bearing elements in buildings provides an opportunity to variate the geometry of building structures as less material are consumed in the same durability and safety are maintained. For the production of HPCC, a cement-concrete matrix with specific characteristics is required: fresh mix must be particularly fluid, delicate and resistant to segregation, while hardened materials must be optimally packaged structure that provides high strength, impermeability and durability. HPCC design technology includes the use of traditional mineral materials, effective chemical admixtures as well as opens opportunity to use waste origin mineral additives as to achieve high workability and strength. The aim of investigation is developing optimal composition applying different micro-fillers, additives and chemical admixtures in according with required properties of HPCC. Designing an optimization experiment using a computer program EDAOPT makes it possible to significantly reduce the amount of experimental work needed from 100 compositions to a total of 12 compositions in multi-factor experiments. Such approach has resulted in optimized cost-effective HPCC matrix composition satisfying the required properties. Additionally, amount of cement was reduced, different amount of pozzolanic micro / nano additive (ash; silica fume; nanosilica; waste metakaolin; waste glass) were used and high flowability, low segregation and high mechanical properties (compression strength in the range 80-120 MPa) HPCC composition was obtained. It was detected what pozzolanic additives (especially waste metakaolin) have direct effect to the durability of HPCC; frost resistance was higher, but penetration depth of chlorides ions in the structure was significant lower compare with reference. It should be noted that at high superplasticizer dosages (2 and 2.5%) Had little influence on the strength of HPCC, but at the same time the mixture become too sticky and viscous, which is not desirable for the practical use in concrete industry. Therefore, the optimal amount of superplasticizer is around 1.5% from the cement. Acknowledgement: “The financial support of European Regional Development Fund project Nr.1.1.1.1/16/A/007 „A New Concept for Sustainable and Nearly Zero-Energy Buildings” is acknowledged”

The influence of used additive ingredients on improving durability in aggressive environments

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Consumables form an integral part of the building materials range. These repair mortars are used in many areas for the repair of reinforced concrete structures (tunnels, bridges, cooling towers, residential buildings, waste water pits, etc.). As a rule, polymer-cement-based scattered reinforcement mortars are used. One of the options is also the use of repair mortars in the rehabilitation of structures where a greater risk of aggressive environments can be expected. The resistance of conventional cementitious composites (mortars and concretes) is very limited. This is related to all the components used - binder, filler, admixture, etc. As a result, the main goal of this contribution is to adjust the composition of the fabric to improve resistance to aggressive environments. In particular, it was to mitigate the effects of SO2 and CO2 gas on the repair mortar. Appropriate choice of raw materials will make it possible to create a more compact mass more resistant to aggressive environments. The effort was to use alternative or secondary raw materials as a partial replacement of the existing components of mash. Both the binder and the filler of commercially available mortar commercially available on the building materials market were replaced. Thereafter, the test specimens of the modified composition were subjected to long-term stress of SO2 and CO2. Subsequently, basic physical-mechanical parameters were tested, the depth of carbonation, chemical and phase analysis were determined.

Controls of limestone aggregate texture on concrete performance

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The production of limestone aggregate exceeds the combined production of basalt and granite aggregate in the USA and many European countries. Aggregate constitutes >70% of concrete volume and has a fundamental role in strength of concrete as a grain-supported composite. Although predominantly monominerallic (>90% calcite), limestone is characterised by significant variations in strength and water absorption which have a profound effect on the compressive strength, mix design and performance of concrete. These differences are the result of the variable textures of limestone which can range from micrite (<4 µm)-supported to sand-sized grain-supported textures to bioconstructions (e.g., coral or coralline red algae), each having variable levels of calcite cementation and grain size that impacts on the angle of internal friction and overall strength of aggregate. In this study, limestone aggregate of high purity (>95% calcite) from the Lower Coralline Limestone Formation with different textures were sampled from adjacent quarries in Malta Island. Two very different limestones that represent extreme cases of limestone textures that are very common varieties of limestone found around the world were selected. Concrete cubes using the British Method mix design for a 25 MPa characteristic strength, were tested with the only difference being the type of limestone aggregate used: 1. Cubes with aggregate from a 50 m thick limestone section named Migra l-Ferha Member (MFM) consisting of large (>2 cm diameter) bioconstructions called rhodoliths embedded in fine grained matrix. Los Angeles abrasion (LAA) test result is 48.5 and 2. Cubes with aggregate produced from grain-supported limestone of the Maghlaq Member (MM) comprising fine sand composed of foraminifera in a fine-grained (4µm) matrix. LAA is 44. Results confirm a consistent 5 MPa difference in concrete cube compressive strength. The relative difference in cube strength is double the difference in LAA which points to the significance of different limestone texture. The varieties of limestone texture can have a significant effect on concrete properties. This study confirms that specifications for limestone aggregate need to be more detailed and include the nature of the limestone determined by petrographical analysis rather than be limited to carbonate mineralogy.

Estimating Concrete Strength by Maturity Method

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Nowadays concrete process on-site can be divided into 7 work phases: design concrete and formwork, shuttering and reinforcing, pouring concrete and supervision, striking and back propping, curing control, determining concrete quality, repair and maintenance. Cur-ing control process plays an important role on strength development and durability of con-crete. Curing takes place immediately after concrete placing and finishing, and involves maintenance of desired moisture and temperature conditions, both at depth and near the surface, for extended periods of time. In order to help to accomplish curing control pro-cess on-site, today wireless sensor/logger for monitoring the temperature of concrete from fresh stage to hardened stage are used. The continuous monitoring of concrete temperature can be used as maturity-based strength estimation of concrete. The field monitoring of concrete temperature can also help with optimizing the formwork removal time, applica-tion of load on the structure, and adjusting the curing temperature of concrete on-site. The paper focuses on the research of real-time temperature and maturity monitoring of concrete. In this paper, the way of using and comparison of different monitoring methods were described. ASTM standard C 1074-98 “Standard Practice for Estimating Concrete Strength by the Maturity Method”, Giatec SmartRock2™ wireless sensor/logger for moni-toring the temperature of concrete from fresh stage to hardened stage and MS Excel soft-ware for temperature modelling for the experiment were used. In the research, one con-crete composition was considered. On-site this concrete was used to erect concrete slabs and was delivered to laboratory for the test. The experiment was divided into three stages: maturity-based strength estimation of concrete was obtained in laboratory using standard C 1074-98, real-time temperature and maturity monitoring of concrete on-site was obtained using Giatec SmartRock2™ wireless sensor and monitoring of concrete temperature was obtained in laboratory using MS Excel software. Based on the research the conclusions were drawn.



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Energy and distributed generation

Real Time Compensation of Voltage Fluctuations in Electrical Networks

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The Electric Network topology has evolved over the past decades from that of a centralized power source to that of a distributed generation one. This change was brought about due to the increase in Renewable Energy Sources such as wind and solar energy. However this evolution has also brought about new challenges for the Power Systems engineers. One of the main challenges was that in the low voltage (LV) network which feeds domestic, commercial and many industrial electricity consumers. Some electrical feeders started to experience a reverse in the power flow due to PV generation exceeding the customer loads. This reversal of current brought about a change of the voltage drop direction along the voltage lines which resulted in over-voltages. The scenario is becoming more common in electrical networks all over the world. However to add to this complexity the future networks shall also experience an increase in loads due to electrical mobility. Unfortunately it is predicted that this will cause under voltages to exist during night-time when the excess solar power is not available. Thus this new scenario requires a voltage regulation system which can be able to lower and higher the LV network voltage in real-time. This paper shall describe the concept of such a system and shall present case studies showing the successful operation of this voltage regulation system.

Energy Efficiency Through Energy Auditing

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In recent years the national energy agency for water and energy are requesting that every company classified as Non-SME adhere to the legal notice LN196 which is concerned with carrying out a detailed energy audit of the industry's premises and its operations according to ISO50002. This paper, shall present findings following several energy audits carried out in local industries in Malta over the years. The principal findings concern electrical and mechanical loads such as lighting, HVAC, production loads and cooling, compressed air and water usage. Production waste is also taken in consideration in this exercise due to the additional energy needed both if recycled or disposed. Following the findings and data analysis, recommended energy improving measures will also be presented and discussed in the paper. Figure 1 is showing an example of one of the energy efficiency measures for reducing the losses in cables through power factor correction. Figure 2 shows the reduction in current achieved with power factor compensation.

DC Microgrids: Concept, Structure, and Control - An Overview

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Power generation has experienced a fundamental shift from centralised to distributed generation in the past years. This shift has been mainly caused by the increase in distributed energy sources, many of which being renewable energy sources (RES). This shift in the power generation concept pushed forward the idea of the microgrid. A microgrid is the integration of a number of distributed power generation systems, energy storage systems, and consumer loads, controlled to form a self sustainable electrical grid system. Microgrids can be AC, DC or a combination of both. However, the DC microgrid concept is highly being researched due to the number of advantages it can offer. This paper provides an overview on the concept, structure, and main control system of DC microgrids. The paper is divided into a number of sections. The first section provides a general introduction on microgrids, while another section presents an overview on DC microgrids. The DC microgrid voltage levels and the control system used to control various RES within a DC microgrid are also discussed. Simulation results achieved from a Simulink/Matlab modelled DC microgrid system are also presented.

Droop Control of Electric Springs for Voltage Stabilization

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In recent years, the integration of renewable energy sources (RES) into the grid has increased significantly. This increase is leading to various power quality problems mainly voltage instability due to their intermittent nature. Various centralised compensators have already been proposed in literature in an attempt to mitigate these problems such as: Static Synchronise compensators (STATCOMs) and static Var Compensators (SVCs). However, centralised compensation is not effective due to the decentralization of energy generation. This can be improved by using smart loads based on the electric spring (ES) concept as these can be configured as decentralised compensation systems using algorithms, such as droop control, to control the voltage at various points along the grid. Moreover, since the smart loads based on the ES concept can offer both active and reactive compensation, they can also be used for frequency regulation and power factor correction. With this concept, the power demand follows the power generation rather than power generation following the load demand. This is a control algorithm that is going to be required as the amount of RES keeps increasing. This paper focuses on the use of interconnected ESs using droop control in order to maintain voltage stability.

Optimal sizing of a grid-connected hybrid power system dedicated to the building

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In this paper an energy management strategy is developed, which ensures an uninterruptible power supply for all priority loads connected to a target building. The hybrid power system (PV-Wind-Diesel) connected to the grid and provided with a storage device is the subject of this feasibility study and optimal sizing. In a case of re-hybridization and to remedy the problem of electricity shortage, this installation is an extension by adding a diesel generator to the DE.DU.ENER.T project installed at Research and Technologies Center of Energy (CRTEn) in Borj-Cedria- Technoparck, Tunisia. DE.DU.ENER.T project's role is to minimize the electricity bill by electrifying partially the laboratory. The evaluation criterion for the analysis was the current net total cost (TNPC) of each system configuration. The sensitivity analysis studied showed the hybrid configuration achievable under the variation of different parameters. The National Renewable Energy Laboratory's Hybrid Optimization Model for Electric Renewable (HOMER) software was utilized as the assessment tool for the present study.

High PV Penetration Mitigation using Reactive Power Control. Case Study: Malta

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Photovoltaic systems (PVs) installations have gained condensable momentum in low voltage (LV) network integration throughout the years due to their economy of scales. PVs offer promising decentralised solutions for electrical power generation decarbonisation. However, high penetration of PVs within grid networks brings about technical challenges mainly associated with supply voltage and network utilisation factors. This paper aims to propose mitigations for voltage challenges based on real LV feeder consisting of 52 potential prosumers. The methodology uses a Monte Carlo simulation approach and evaluates two worse case PV penetration scenarios. Reactive power dispatch from PVs will be utilised according to the penetration levels to mitigate decentralised supply voltage variations. A pool of real-life 1860 consumer and 1100 PV production profiles provides the basis for stochastic data analysis. The proposed mitigation may allow higher PV penetration without any voltage issues while the utilisation factor of the feeder would require further careful monitoring.

Energy and Water Nexus within an Urban Scenario: A Maltese household

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The integration of renewables in the urban context is increasing. Concepts for self-consumption may mitigate high penetration impacts on the grid. This paper puts forward the concept of self-consumption from PV generation into hot water supplies for a household. A mathematical simulation framework is described to analyse the thermodynamic processes taking place within an electric boiler (EB). This thermal capacity of the EB and the energy provided to its heating element may satisfy the domestic hot water demand with excess PV generation. The framework allows for a load shifting strategy to utilise PV generated electricity instead of exporting to the grid, thereby storing energy as heated water. Two case studies show that significant evening load shifting is possible to sustain the domestic hot water demand. The load shifting strategy has increased the self-consumption of the PV system while providing a sufficient domestic hot water supply.

Design and Performance Evaluation of an Efficient Boost Converter for Renewable Energy Applications

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In this paper an efficient DC – DC boost converter is designed to achieve a fixed output voltage which can be used with distributed energy resources (DER's). simulation and hardware implementation of a DC-DC boost converter for a fixed output voltage. The boost converter is usually designed for a large range of varying input voltage. The customized design of boost converter is accomplished by analysing the design equations and optimizing them to operate the converter in continuous conduction mode (CCM). To determine the ratings of the selected components a detailed description is given. An efficient PI controller is designed to ensure fast and accurate response. The stability is ensured by carefully choosing the parameters of PI controller. Simulation and experimental results clearly indicate the increase in efficiency even under low duty cycles. This work is applied for maximum power point tracking of a 40W PV module.

Enhancement of Frequency Response Capability of Grid Connected Photovoltaics

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As the penetration levels of Photovoltaic systems (PVGs) progresses in the utility-scale distribution networks, the effective inertia due to the constant power factor 'Negative Loading' is also reduced. One important regulation featured in the 'Network Codes' of the ENTSO-E is the requirement of frequency response by the renewable energy sources. This is generally provided by the PVGs at the sub-transmission levels. However, when the grid size is small, the dominating system is substantially a low or a medium voltage network. Due to the rising number of the PVGs in such networks, the voltage is not constant at the PCC, acerbated with significant value of impedance as seen by the source. Therefore, rooftop PVGs also must cater to frequency response services. These services are provided, generally with the help of a negative drooping of the active power. However, the droop control is a proportional controller, which can have detrimental small signal stability effects, and hence, for the grid-connected operation of the PVGs, a P-D control or an inertial control, which mimics the swing equation of the synchronous generator, is deployed for harnessing inertial response from the PVs in case of over frequencies. The efficacy of the controller has been tested for different frequency conditions, and it is observed that the PVG, even under weak grid conditions, can deliver frequency response, enhanced by inertial support.



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Environmental Behaviour, Economics & Policy

Taxing waste to stimulate home composting - behavioural consequences

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Biodegradable waste constitutes the largest single fraction of municipal solid waste, poses treatment and land-filling problems and is subject to specific targets in European Union member states. Despite the environmental and economic benefits of home-composting and its potential to contribute to a circular economy, the determinants of this particular waste stream, and the potential of a waste tax to induce it, has received little attention in economics. The present study specifically examines the potential of a waste tax to reduce biodegradable waste and encourage substitution into composting. Furthermore, with a view to examining the wider potential effects of the tax, the study also tests possible unintended consequences. These include the effect of a tax label (calling it a tax as opposed to a fee), the potential that the tax stimulates illegal waste disposal intent and the risk that the tax crowds out moral motivation to compost voluntarily. Data is drawn from a nationally representative survey (n = 1,037) in Malta, in which respondents were randomly assigned to different tax treatments. The study finds that in the absence of a tax, access to a garden or rural area enhances the probability of composting, while perceptions of nuisance significantly suppress it. The introduction of a fee and raising its level, but also simply labelling it as a "Pay as You Throw Tax" significantly reduce waste disposal intent, encouraging substitution into home-composting. The findings also suggest, however, that there is a significant risk of stimulating illegal waste disposal intent. Substitution is mainly driven by the reactions of household members that hold government in low trust. Higher taxes also negatively impact moral motivation among some households. These findings suggest that introducing waste taxes may generate behavioural reactions beyond those that respond to price. Some of these can partly off-set the expected economic benefits of waste reduction and composting.

Socio-Economic Insights for Environmental Policy in Malta: Evidence from a Nationally - Representative Survey

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This article reports some of the headline findings from a nationally-representative survey (n=507) conducted in Malta, which sought to understand environmental attitudes and behaviours with a view to guiding policy. Correlation analysis enabled the identification of broad relationships, while composite variables that synthesize information on attitudes, concern, knowledge and behaviour respectively were used as the dependent variables in multivariate regression analysis with a view to parsing out the effects of their main socio-economic determinants. We find strong levels of awareness of environmental problems faced by Malta particularly with regard to urban and development issues like traffic, air pollution and lack of open spaces. We also find that pro-environmental behaviour has largely been concentrated in those areas where there is a strong, government-backed infrastructure to facilitate such activities. Environmental awareness, interest and behaviour is clearly positively-correlated with respondents' level of education, a relationship that survives in multivariate analysis. These results have some interesting implications for environmental policy in Malta, which we also outline.

Domain & Context Heterogeneity in Pro-environmental Behaviour

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In the face of costly environmental degradation and the enduring failure to reverse this through adequate and timely intervention, voluntary pro-environmental behaviour by private citizens offers some hope to address market failure at its core, shifting demand away from environmentally damaging goods and services to pro-environmental choices. Evidence to date suggests that such choices are a combination of intrinsic (awareness, preferences, moral motives) and extrinsic motivators/barriers (like convenience, infrastructure and pricing), in domains as diverse as energy conservation, consumption of eco-labelled products, transportation choices, and recycling. Some scholarly work has recently examined the potential of spill-overs from one domain to another but less attention has been paid to the worrying prospect of inconsistent behaviour in diverse contexts. This study assesses environmental behaviour in various domains (including eco-label purchases, waste, energy, water and transportation choices inter alia), in two main contexts: at home and at work. Conceptually, we posit that inconsistency may be explained by diverse motivators/barriers in different contexts, and mitigated by the threat of cognitive dissonance. We employ a unique dataset derived from a survey conducted among a sample of over 800 employees in Malta. Our data indicates that respondents do exhibit significantly diversity in their choices, with pro-environmental behaviours at home out-performing those at work across most domains. Our initial results also suggest that perceived lack of convenience at work accounts for much of this inconsistency, after controlling for variance in other intrinsic and extrinsic determinants. Strategies aimed a facilitating voluntary pro-environmental behaviour would do well to examine home and work contexts simultaneously in order to avoid attrition in pro-environmental outcomes.

Engaging in sharing economy: a case study in the transportation sector

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The increased use of private vehicles has resulted in numerous health and environmental issues, raising concerns among citizens and pressures on authorities to alleviate the problem. Traffic congestion and insufficient parking availability also result in time and productivity losses. In order to mitigate this problem, typical solutions include stimulating modal shifts towards public transport. Car-sharing has more recently emerged as a novel solution - a way to rent cars stationed around cities to be used for the duration of a trip. This study presents a hypothetical car-sharing service to respondents to an online survey aimed at determining what initial conditions and design would stimulate them to take up this initiative. Respondents were primed with different information on service providers and subsequently asked for their willingness-to-pay. As the survey was rolled out ahead and after the launch of an actual car-sharing service set-up in Malta, this enabled the testing of differences in WTP in both a hypothetical and actual scenario. Difference-in-means and regression analysis were then applied to the data collected to test what determines willingness to engage and pay. Initial results show that both engagement and willingness to pay are negative in cars per capita within households. Willingness to pay responds positively to income, and negatively to expected usage. Few would be willing to sell their car to rely on car sharing services. Respondents are more likely to share within a scheme launched by the private (rather than public) sector and that their propensity to share in a hypothetical scenario (pre-launch) were much more favourable than in practise (post launch). This has important implications not only for policy and service providers but also for the literature that relies on contingent markets for analysis.

An economic analysis of the determinants of greening business

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The threats to economic development and social welfare in the face of rapid depletion of natural resources and negative environmental impact driven by traditional economic and business models, have led policy-makers across the globe to seek interventions that promote greener practise among households and firms. To date the two areas of study have remained fairly separate. It is well understood that pro-environmental motivation and norms are key determinants of behaviour in households, while profits (the bottom line) is a key motivator for business decisions. In turn better profits can arise from a reduction in costs, increases in revenue. Policy interventions can shift the cost-benefit ratio of different business decisions. But the owner's own moral sense of social responsibility towards the environment has received little attention. We examine the main motivators for businesses to employ environmental practices in their operations, the extent to which they are profit-driven, the influence of policy and the influence of the owners' own values. We also assess the propensity of firms to improve their environmental performance in the face of policy alternatives. Data will be gathered from an online survey sent out to businesses with econometric analysis to parse out effects.

Decoupling Carbon Dioxide Emissions and Economic Development In Small States: The Role Of Governance

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This chapter examines the relationship between economic development, governance and carbon dioxide (CO_2) emissions among small states worldwide. Conceptually, the paper uses an Environmental Kuznets Curve (EKC) framework which hypothesizes an inverted U-shaped relationship between GDP and CO_2 emissions. It extends this framework by incorporating governance, with the purpose of capturing the extent to which this can decouple the relationship between GDP and pollution within the context of small states. Random and Fixed Effects econometric estimation methods are employed on a panel dataset covering 34 small states over the period 2002-2015, including Carbon Emissions, GDP per capita and six key governance measures as set out by the World Bank. Preliminary results confirm the existence and validity of the hypothesised inverted U-shape relationship between GDP and carbon emissions. This confirms the existence of a conventional EKC for the small states under review. Additionally, our results also indicate that good governance, defined as "rule of law" within a country (a construct including protection of property rights and the perceived quality of public institutions) is a key determinant in CO_2 emissions reductions, and one that manifests a statistically-significant and negative relationship with emissions across different econometric specifications. This study also examines the point at which GDP and CO_2 emissions decouple, both with and without governance, finding that good governance effectively shifts the traditional EKC. The results suggest that governance, and in particular rule of law, acts in tandem with economic development to bring about reductions in CO_2 emissions. In the light of small states' well-documented issues with high (per capita) governance costs due to indivisibilities and lack of economies of scale, this presents an interesting challenge to governments in small states, for which some solutions are also proposed.

Trust and Willingness to pay to conserve land. A case study at Zonqor Point

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Recent research in the domain of pro-environmental behaviour suggests that voluntary cooperation with state-sponsored schemes and political preferences may be linked. This study examines the impact of trust in government on individual willingness to pay (WTP) for protecting landscape in one of the most densely populated countries in the world: Malta. Utilising a contingent valuation (CV) questionnaire, individuals were invited to state a monetary value for the protection of the land under threat of development. The results indicate that willingness to pay is predicted by relevant socio-economic determinants, including age, residence and workplace proximity. Mistrust in government also yielded a higher WTP, demonstrating a higher desire to pay to stop the development from going ahead. From a scholarly perspective, the findings suggest that future CV studies would benefit by collecting data on trust in the agency responsible for protecting or developing the environmental asset in question.

Environmental Engagement and Spirituality in the context of secularisation

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The relationship between religion and environmental attitudes/behaviour has long been philosophically debated. One question receiving scholarly attention in quantitative social science is whether Judeo-Christian religions have an inherently negative effect on environmental concern, given their premise that humanity has dominion over nature, or conversely whether they stimulate environmental protection, given their ethic of stewardship. Empirical results are diverse and the relationship seems to vary in size and direction, depending on definitions and the method of investigation adopted. But an important phenomenon which has received far less attention (arguably because it is harder to measure) is that of spirituality, within/out the context of a religion. The phenomenon seems to be growing in empirical relevance in Western societies as more individuals move away from institutionalized, formalized (and perhaps compromised) forms of religion. This paper contributes to the literature by examining the prospect that spirituality offers an important predictor of environmentalism, employing nationally representative data (n=1057) from Malta, a predominantly Roman Catholic European Union country where religious participation is in decline. The dataset includes measures of religiosity, spirituality, environmental engagement and relevant socio-economic co-determinants. Our findings confirm the usual co-determinants of environmental engagement (e.g. education) and detect a positive link between some types of environmental engagement and religious engagement. We further find spirituality, whether or not combined with religious participation to be a strong predictor of environmental engagement. In the context of increasing religious disaffiliation, the prospect that spiritual processes beget environmental engagement may be a positive one for improved environmental outcomes.

Biodiversity conservation: what people know and what they do

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Despite the growing list of environmental regulations and directives in countries around the world, concerns regarding the continued degradation of our natural environment persist. Carbon dioxide emissions have increased by over 22% globally between 2005 and 2014 while the International Union for the Conservation of Nature estimates that over 27% of all mammal, bird and amphibian species in the world are at risk of irreversible extinction, largely due to human activity. It becomes increasingly important to seek ways to promote and encourage voluntary pro-environmental behaviour by private citizens, not simply to comply with regulations but also to go beyond the often politically motivated confines of such policies. One of the key prerequisites identified in the literature when it comes to activating sustainable choices is the individual's level of knowledge and awareness of environmental problems and their causes. The idea is that such knowledge helps to activate various norms like social concern, altruism, guilt and conformity, which may in turn increase individual proclivity towards pro-environmental behaviours. Yet a growing number of studies have found a clear gap between environmental awareness and behaviour, which suggests that the relationship between the two may not be as clear as expected. In this paper, we seek to analyse the existence of this gap in the domain of biodiversity conservation. We use a novel dataset drawn from a nationally-representative survey conducted among households in a European Union member state (Malta) which contains detailed questions related to various aspects of biodiversity awareness, concern and knowledge from ecosystem services to the protected status of different species, to the practical issue of permits required for various activities that may impact biodiversity. We further consider the relationship of these variables to various pro-environmental behaviours in the biodiversity sphere (and beyond), including financial donations to environmental groups, uprooting of trees and reporting the sighting of particular species. Together with demographics and socio-economic status of respondents, we also seek to control for the various aspects of 'pro-environmental consciousness' including general attitudes towards the environment, perceptions regarding regulatory efficacy and beliefs on the attribution of blame for environmental problems. The results from this paper shall contribute towards the debate on effective communication strategies in relation to environmental information campaigns since apart from underlining the importance (or otherwise) of information and education, the depth of the survey enables us to tease out which aspects of knowledge and awareness should be the focus of such campaigns in order to induce effective behavioural changes.

Political preferences and Voluntary Pro Environmental Behaviour

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The quest to understand what stimulates voluntary pro-environmental cooperation has garnered considerable interest in behavioural environmental economics, not least because of the recognition that fiscal and regulatory measures can incur prohibitive political risks. However, it is increasingly evident that political preferences are a material consideration in stimulating voluntary participation. This study makes a contribution to the evolving literature on political preferences and pro-environmental behaviour (PEB) by assessing this relationship across diverse domains (waste, energy use and biodiversity) and by testing the potential role of various political preferences: political interest, voting patterns, attitudes towards intervention and trust in government at the municipal, national and supranational level. The empirical approach involves setting up a conceptual framework for explaining pro-environmental behaviour, the collection of data from a representative sample of the population of a European Union member state (Malta) regarding uptake of voluntary environmental schemes and the analysis of this data using econometric techniques to isolate the impacts of each determinant. Once the usual demographics are controlled for, the results indicate that voluntary PEB is higher among those with positive attitudes towards government intervention, and with higher levels of trust in the government relevant to the scheme. Stronger levels of PEB are also systematically observed among those with higher levels of political interest. This has important implications in terms of the potential it offers to target an easily identifiable demographic for the early adoption of PEB through relevant communication channels.



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Restoration of Reinforced Concrete Structures

The Appraisal of Reinforced Concrete Heritage Structures

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Reinforced concrete structures present significant challenges as a result of degradation with time, due to the inherent material properties, structural systems and factors related to the external environment. The conservation strategies for historic reinforced concrete structures are based on the outcomes of appraisal of materials and structures. The paper presents a framework for the appraisal of reinforced concrete historic structures to support informed conservation strategies.

In the conservation of heritage structures in concrete, the understanding of the structure and the degradation mechanisms in the particular environment are crucial and an effective approach for intervention requires a structured methodology for the appraisal of materials and structure leading to a thorough appreciation of the historic concrete structure.

The assessment of structures is based on preliminary and detailed investigations including documentation; field inspection and condition surveys; sampling and material testing; documentation with respect to design, materials, construction and service history. The evaluation is required to cover the structure and its components, geometry, materials, structure, rehabilitation options including alternatives and cost. Inspections of structures are required for the idenitfication, classification and mapping of degradation. These are supported through additional investigations including non-destructive, non-invasive methods and destructive tests, especially when deterioration is observed.

The framework for appraisal is based on Records and Documentation, Classification and Mapping of Degradation, Materials Assessment, Structural Assessment and Environmental Assessment. The framework presents a structural approach leading to effective conservation strategies for reinforced concrete heritage structures. The investigation of the Historic Reinforced Concrete Water Tower at the Public Abattoir in Malta was carried out with reference to the framework for appraisal presented. The appraisal provided documentation, materials and structural performance and environmental data for the definition of a conservation strategy for the historic structure.

Strategy for the Restoration of the Reinforced Concrete Water Tower

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The Reinforced concrete water tower at the Public Abattoir in Marsa Malta, was constructed in the 1930s and is considered to be an industrial heritge monument. It consists of a large reinforced concrete structure, c.14.5 m high with a tank having an internal diameter of c.9.5m. The tank consists of a shell structure with a cylindrical drum resting on a truncated conical structure with a dome at the base and with ring beams at the top and between each element. The tank rests on a ring beam supported on 12 slender reinforced concrete columns with a reinforced concrete foundation ring at the base. The structure has been repaired in the 1970s and the repair intervention included the strengthening of the 12 columns using a reinforced concrete jacket. The tank used to be filled in with brackish and sea water. The age of the structure including the use of sea water in the tank, its location close to the sea in the industrial area of the Grand Harbour and other aspects have contributed to its degradation. This is primarily due to the corrosion of its reinforcement, extensive on the south facing side of the tank. Carbonation of concrete and chloride ion penetration through the concrete structure resulted in the corrosion of reinforcement, cracking, spalling and delamination with loss of concrete section and loss of reinforcement. The combined effects of corrosion-related processes, wet and dry cycles and stresses in the structure in operation, all contributed to degradation. The strategy for its restoration is based on records and documentation, identification, classification and mapping of defects, assessment of materials including non-destructive and destructive testing, assessment of the structure, structural modelling and analysis. The restoration interventions are intended to reinstate the structure and respect the chracteristics, geometry, structural performance of the Water Tower and its functions over time. To achieve these objectives various specific intervetions are required in different parts of the structure including surface treatment; patch repair relying on repair mortars and polymer based materials; injection including epoxy injection; electrochemical repair including re-alkalisation and chloride extraction and external strengthening. External strengtheing is proposed through the application of Ultra High Durability Concete (UHDC), a high strength, high durability self-healing concrete based on nano-additives: An ultra high durability self compacting fibre reinfroced concrete jacketing for the 12 reinforced concrete columns; textile reinforced concrete for the curved elements of the water tower. In addiiton a monitoring strategy is designed to assess the structure and restoration interventions, throguhout the life-time of the structre and includes a sensor network system based on three phases: structural health monitoring, durabity monitoring, environmental monitoring. The Water Tower restoration project presents a first comprehensive intervention for the conservation of a historic reinforced concrete structure in Malta. In this regard it serves as a strategic innovative research platform for performance assessment and long-term monitoring of interventions.

Structural Assessment of a Reinforced Concrete Water Tower

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The paper presents a structural appraisal of a reinforced concrete water tower at the Public Abattoir in Malta. The water tower was constructed in the first half of the 20th century and consists in a reinforced concrete thin shell structure supported on twelve columns. Detailed drawings and a refined 3D model were prepared based on detailed site measurements of the structure. The concrete was assessed through non-destructive tests and with reference to extracted concrete core samples from different parts of the structure and extracted steel reinforcement samples. Detailed deterioration mapping was conducted for the entire structure. This data was used to model the structure and analyse it through finite element models intended to determine the structural performance of the water tower.

A preliminary linear finite element analysis was performed first using Scia Engineer in order to determine the internal forces acting within specific members of the structure with reference to two cases. The first model consisted in a non-deteriorated water tower. Through historic research, water tower surveys and materials testing, a numerical model was created in order to achieve an understanding of the original design of the water tower and how it was actually built on site. The reinforcement present within the water tower and the required reinforcement as per specific load cases derived from the numerical model were compared in order to understand to the design and its performance when constructed. The second model consisted of the deteriorated scenario. The deterioration mapping and material properties obtained from the tests conducted on materials on site, were used to model the structure in its existing condition. The same load cases as for the first model were considered to identify failure points and mechanisms acting within the deteriorated water.

The structural performance was then verified through an additional finite element analysis using SAP 2000, conducted for the two cases: as originally constructed and the structure in the degraded state. In addition, a non-linear analysis of the structure was performed for the assessment of the ultimate and serviceability state for the non-degraded and degraded state. The finite element analysis provided important information for the understanding of performance of the structure as originally designed and constructed and the structure in the degraded state. The information on the structural performance obtained through FEM is required in the consideration and design of structural repair interventions for the reinstatement of the water tower.

The Mechanical and Durability Performance of Ultra High Durability Concrete

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Reinforced concrete structures and Infrastructure in coastal areas are exposed to aggressive environments and experience significant time-dependent durability problems, which require continuous maintenance. Typical defects in structures under high exposure conditions include excessive corrosion, accompanied by cracking and spalling of the concrete. The use of innovative materials, specifically Ultra High Durability Concrete (UHDC), leads to an upgrade of the Ultra high performance concrete concept, to improve the structural durability and long-term performance under Extremely Aggressive Exposure conditions as in the case of coastal areas. UHDC ca be achieved though specific constituents including self healing admixtures and nano additives which promote durability and life-time engineering design of infrastructure. Ultra high durability concrete was developed as a self-compacting, self-healing, fibre-reinforced concrete intended for aggreassive environments in coastal areas. The performance of the UHDC developed with specific constituents and different nano-additives was assessed with respect to the fresh and hardened propeties. The mechanical performance of the UHDC was analysed through the development of strength (compressive and flexural strength) and Ultrasonic Pulse Velocity, with time. The durablity performance was investigated with reference to vacuum saturation porosity, Mercury Intrusion Porosimetry, Chloride Penetration and Sorption. The paper presents a first assessment of the material fresh, mechanical and durablity properties. The UHDC developed performed satisfactorily as a self-compacting concrete with high strength with resepct to compressive and flexural strength. The material demonstrated also a very high durability performance for all test variables considered in the research. The assessment of the material confirmed the suitability of the UHDC for highly aggressive environments.

Thermal Imaging Measurements for Assessing Structural Integrity of a Reinforced Concrete Water Tower

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Reinforced concrete structures may exhibit degradation as they age. Thermal imaging captured using an infra-red camera can be used as a non-destructive and non-invasive technique to identify the structural health of such structures by providing a heat map which can be analysed through examination of the differences in temperature. A healthy concrete region generally exhibits a homogeneous temperature while degraded regions of the concrete tend to exhibit changes and variations in temperature. The paper presents a preliminary analysis based on thermal imaging for the assessment of a historic reinforced concrete water tower structure. Thermal imaging is used for non-destructive assessment, to identify and assess any anomalies in the structure including degradation of materials. Significant information can be obtained through the gathered data and image analysis. The technique requires an understanding of mechanisms involved in deterioration, local conditions and adequate calibration. Patterns in results were identified in the investigation and variations in the concrete could be defined and classified including: detached or delaminated surface concrete which is disconnected from the main structure; cracks in the structure; reinforcement at the surface; previous repair interventions. Differences in moisture at the surface and defects can be detected through differences in the temperature. The investigation reported shows that thermal imaging can be effectively used to support routine inspections of reinforced concrete structures to assess degradation. The technique presents a rapid assessment method which can be used in conjunction with other non-destructive assessment methods for the assessment of structures.

The Structural Health Monitoring of a Reinforced Concrete Water Tower

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Structures can suffer long-term damage as a result of actions and environmental conditions and exposure with time resulting in a gradual deterioration in performance. Structural repair interventions and strengthening of structures are relatively costly. Structural health monitoring (SHM) can mitigate the high repair costs by detecting early on and measuring damage phenomena with time. Structural Health Monitoring can mitigate long-term damage by continuously monitoring the structural condition of key elements and parts of the structure. SHM can be particularly important in the case of new structures, damaged structures and in particular in structures which have been repaired or strengthened, in order to measure their performance with time. A Structural Health Monitoring strategy is applied to a reinforced concrete water tower constructed in the 1930s, for which a repair and strengthening intervention is considered. The objective of SHM is to monitor the performance of the existing materials and structural elements and the repair interventions including the new materials used in the repair intervention. The SHM strategy for the water tower refers to key performance indicators, critical components and elements in various parts of the structure, with reference to specific actions. The SHM is based on various technologies and sensor network systems which are intended to monitor the performance of the water tower with time. The water tower SHM and degradation monitoring framework proposed, based on a sensor network system, is assessed within a wider strategy for the monitoring of performance of repair interventions on deteriorated reinforced concrete structures.

Biological Diversity on an Industrial Heritage Structure: The Case Study of a 20th Century Water Tower

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The objective of this study was to assess the biological colonization on the historic reinforced concrete water tower at the Civil Abattoir, Marsa, Malta as part of a restoration project. Given that restoration works were going to be carried out on this 20th century Industrial Heritage structure it was important to characterize the biological patina present prior restoration works for documentation and conservation purposes. In an effort to identify and document the organisms present the outer surfaces of the structrue was surveyed and samples were systematically collected and identified utilising morphological and chemical studies.

The outer surfaces of the examined structure were found to be colonized by saxicolous crustose lichens with predominant species belonging to the genera of Flavoplaca, Myriolecis, Lecania, Variospora and Xanthocarpia. The occurrence and development of lichen communities was found to be restricted by local environmental conditions. The macrofloral patterns varied according to aspect, inclination and according to structural elements and stability of the substratum. South facing vertical walls were devoid of any lichens due to the severe deterioration and extensive surface detachment areas. In contrast north and west facing vertical surfaces receiving diffuse sunlight were colonized by a variety of species belonging to the genus Myriolecis, Lecania and Xanthocarpia, particularly in crevices between exposed aggregates on rough surfaces. Horizontal surfaces receiving direct sunlight at the top of the structure were dominated by an orange black crust dominated mostly by species of Variospora and Xanthocarpia. Exposed metal structures favoured another community type dominated by Flavoplaca and Lecanora species both in shaded and exposed locations.

The results obtained from this reconnaissance assessment provided an opportunity to gather information on lichen biodiversity and community types present on early 20th century concrete material as an artificial substrate, as part of an integrated restoration project. This assessment presents a first study on lichen biodiversity on historic concrete in the Maltese Islands and serves as a base study for future invetigation in order to better understand the behaviour of lichens communities on this particular substrate type.



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Energy Efficiency & Renewable Energy

Household Energy Consumption and Solar PV Energy Generation: A case study in Malta

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The household energy consumption is an essential parameter to design renewable energy generation systems, to carry out demand response studies and to enhance the performance of energy management units. Nevertheless only few studies in literature analyze the user's electrical consumption profile in detail. Hourly data are often used and devices are assumed to operate at their rated power. In this paper, the electrical consumption profile of a dwelling located in Malta is analyzed in detail. The electrical demand has been monitored for over one year and data are available with a resolution of 30 seconds. Besides the electrical demand, measurements of the electricity produced by a photovoltaic system, installed on the roof-top of the dwelling, have also been performed. To evaluate the effect of different solar PV system sizes, a parametric analysis has been carried out. It shows that the self-consumed electricity only slightly increases, while the surplus of electricity injected into the grid grows at a faster rate. An oversized PV system will cause a large amount of electricity to be injected into the grid. In high market penetration scenarios of solar PV, this will possibly incur curtailment and jeopardize the grid safety and reliability. Different strategies are discussed to increase the self-consumed electricity and reduce the excess electricity injected into the grid.

Urban Wind Turbines for Smart Cities: capturing the perceptions of EU experts

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This research aims to analyze the perception of experts in the field of wind energy generation as shapers of renewable energy policy in Europe. Experts as members of society have an impact on social perception of renewable technologies. They can lead influential roles in changing societies and governments' policy regarding dependency on grid-generated fossil fuels. Wind power continues to have a major role as part of the emerging global shift to diversify sources of the energy supply and its mix, to spur sustainable development and security of energy supply. According to the Global Wind Energy Council (GWEC), the deployment of wind power has more than tripled since 2007, bringing the total installed global capacity to 486.8GW at the end of 2016. This research captured responses of 51 scientists researching wind turbines aspiring to improve their structural, electrical and mechanical performance. This research presented them with 10 common visual scenarios of WT integration scenarios. It is acknowledged that the experts will not only judge the visual aspects of the photographs but scientific knowledge will play a major part in their judgment. The authors were keen to understand the experts' perceptions of siting, sizing, proximity and length of exposure preferences, as well as the experts' perceptions of the maturity of urban wind turbine technologies.

Influence of temperature on the growth of microalgae Chlorella vulgaris in laboratory batch cultures

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Microalgae are a promising source of renewable energy. However, large-scale biomass production is currently limited due to low biomass productivity largely as a result of unsuitable cultivation conditions in bioreactors and open ponds. Temperature is one of the most important factors affecting microalgae growth. It is crucial to evaluate the optimal temperature for cultivation of specific microalgae strain because of different temperature requirements of microalgae. There is a variation in optimal cultivation temperature reported in the literature, moreover the impact of low temperature on microalgae growth is rarely considered. In order to assess the optimum temperature and the effect of low temperature on the growth of green microalgae Chlorella vulgaris 211-11j we tested environmental temperatures ranging from 8 to 32 °C. The results indicate that C. vulgaris 211-11j exhibit optimal growth at wide temperature range from 20 to 28 °C and is therefore suitable for cultivation in outdoor open ponds exposed to changing environmental temperature. In the present study we demonstrate that C. vulgaris has high adaptability to various temperatures and in particularly good acclimation capability to low temperatures.

Territorial sustainability assessment for biogas production: an integrated GIS and Multi Criteria Analysis for the Latvian context

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The aim of this work is to perform a sustainability assessment for biogas production in Latvia, developing a methodology that could evaluate the biogas sustainability, defining the factors that mainly influence the biogas plant sustainability and ,finally, identifying the more sustainable area to set a biogas plant in Latvia. The method implemented consists in an integrated GIS and multi – criteria analysis (MCA) combining geographical information and environmental, economic and social data. In order to develop the multi-criteria analysis different weights have been assessed. Through the analysis six scenarios have been identified and prioritized according to the different area of sustainability. Finally, the main factors influencing the analysis are identified through the localization of 40 plants in the resulting layer. The study, and thus the model, is set in the Latvian context might be applied and replicable to other countries by changing, when necessary, the indicators used. It is possible to apply the same study to the Italian context, indeed, even if due to the territory conformation and to the different legislation the restriction to employ could be different.

Environmental evaluation of heating system based on life cycle assessment - comparison of classic and energy independent system

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The paper deals with the question whether the optimization of energy systems to reduce the building's environmental performance will also affect the embodied impacts of energy systems. It also examines what is the ratio of embodied and operational impacts of energy systems. A system based on renewable resources is designed. It is completely independent of external supplies of any energy. It is compared to a system commonly used in family houses in Central Europe, which is dependent on gas and electricity supplies. The comparison includes the environmental impacts associated with energy consumption for heating and hot water preparation and the impacts associated with the production of all heating system components. The results shows, that the impacts associated with component production (embodied impacts) are minor compared to operating energy consumption but are not negligible.

Supporting Consumer Co-Ownership in Renewable Energies: SCORE H2020 project

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An on-going Horizon 2020 project, named "SCORE" (Supporting Consumer Co-Ownership in Renewable Energies), is focused on Sustainable Development Goal-SDG11. Particularly, this project aims at overcoming the usage of energy from fossil sources in favor of renewable energy sources (RES). In particular, technical, financial and social innovations are crucial prerequisites for a fruitful transition from fossil fuels to RES. It is essential to build new energy infrastructure and motivate consumers to change their consumption behaviors to balance demand with a volatile energy supply. Moreover, increasing acceptance of new technologies is another issue to be considered. In this context, Consumer Stock Ownership Plans (CSOPs) in RE has proven to be an essential cornerstone to the overall success of energy transition. When consumers acquire ownership in RE, they become prosumers. Into this, they are more beneficial by (i) generating a part of the energy they consume (ii) reducing their overall expenditure for energy (iii) receiving a second source of income from the sale of excess production. The first project's task was the identification and description of different case studies. Afterward, for each case study, several retrofit alternatives are defined. In this framework, the main goal of the present study is to illustrate how the alternatives are defined, how indicators have been selected and assessed, and how the project aims at involving the citizen in CSOP Model. The next step is building an evaluative matrix, which later makes it possible to analyze the feasibility of the different case studies and choose the best retrofit alternative through a Multi-Criteria Analysis (MCA).



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Disaster Resilience

Evaluation of Multi-Hazard Early Warning Systems (MHEWS): Case studies in Myanmar, and Sri Lanka

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A field based research work carried out to evaluate the important aspects of Multi-Hazard Early Warning Systems (MHEWS) in Myanmar and Sri Lanka and to identify opportunities, gaps and barriers in MHEWs. An evaluation framework in the form of questionnaire survey was developed through a thorough literature review and studying the existing frameworks of both countries. Furthermore, the compliance to the global frameworks such as Sendai framework, Sustainable Development Goals (SDG) and Paris Climate Convention (UNFCCC) were considered when developing the framework. Same questionnaire survey was used to gather information from two villages in Myanmar and Sri Lanka each to understand the existing MHEWS and preferred warning systems. Subject experts were interviewed to verify the information gathered. When analyzing the data, the reliability and efficient lead time had a positive correlation with successful response towards the warning. The cascading events lead to early warning with the stakeholders, operational procedures involved were also observed whom the warning process effectiveness depended on. It was further revealed that even though the output of a warning depend on such aspects, the effectiveness depends on much border input context in policies, and technology. The influence of the differences in the governing system of two countries have in the early warning and evacuation process also identified through this study. Furthermore, when having the facilitation to involve community in defining the early warning process to include the community indigenous knowledge and experience are identified as important aspect the governing structures should focused. It was observed a high level of knowledge gap in technology usage in two case study countries.

Island Vulnerabilities: A research strategy for the Assessment of Perception of Island Communities in the Maldives

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Vulnerability is a complex concept that embraces different factors including social, economic, cultural and environmental components (Baldacchino, 2012). The correlation between vulnerability and environmental threats depends on the geographical conditions of the specific islands rather than on general assumptions. For small Island or archipelagic states the geographical conditions are not determined only by their size and location but possibly even by their remoteness and fragmentation. The transfer of technical knowledge from the universal to the particular context may not necessarily reflect and respect the needs of the communities. This may in the long-term jeopardise the locals' resilience to hazards. This research acknowledges that the islands' communities may have the skills, the resources and the initiative (capacity) to act to reach their development goals and address their vulnerabilities. The objective of this study is to draw a research strategy that maps the island communities's sense of vulnerability to environmental and natural hazards as part of the socio-environment relations within the specific geographical context. It is here believed that knowing the islanders' perception of their vulnerability would enrich the position of policy makers, civil protection entities and Higher Education Institutions. This would in turn allow the responsible entities to draw a hazard mitigation strategy that includes local communities. This study proposes a research methodology on how to enhance the disaster resilience amongst coastal communities in different islands in the Maldives through the collaboration of the local communities and technical experts. This research plan draws on a participatory bottom-up approach to explore the potential adaptation strategies of the community depending on their perception of their own vulnerability to the specific context of the island they inhabit.

An Overview of Existing Digital Platforms in Disaster Emergency Response Stage

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Emergency Response Stage actions activate immediately after the disaster event or when an emergency event is imminent and continue until the beginning of the recovery stage. During this stage, there is a necessity of accessing and sharing of disaster-related information related to affected communities and infrastructure immediately. Therefore, the necessity of having an effective disaster response information management platform is highlighted to work on a common integrated communication platform for all the disaster emergency response stakeholders such as victims, government institutions, external organizations and communities. During the last two decades, many digital communication platforms were developed, some were digital alterations to the conventional media channels while there was a completely new Information Technology-based interactive networked communication platforms developed referred as Social Media. Moreover, during the last decade there were many attempts to develop fully dedicated digital communication platforms, web tools and mobile phone applications for emergency response management. Under this research study, existing communication platforms which have been developed over the last two decades were identified and their functional behaviours were studied. These platforms were then compared against each other based on their activities in the emergency disaster response stage. Some of the gaps and barriers in using the digital platforms and feasibility of the application of technological platforms in Sri Lanka were identified through a questionnaire survey. The research outputs are useful to explore more on emergency response mechanisms and developing effective community-based communication platforms for coordinating emergency response work tasks.

The upstream-downstream interface of an end-to-end tsunami early warning and mitigation system; the cases of Indonesia and Sri Lanka

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After the catastrophe of 2004 Indian ocean tsunami, the governments and international organisations around the world have been keen on developing warning system to prepare for tsunami disasters and to mitigate the casualties through evacuation. A typical tsunami early warning system consists of two main processes of upstream and downstream, the former to detect the earthquake and predict the possibility and impact of the tsunami, and the latter to disseminate the warnings to people and evacuate them to safer places. Between these two, occurs the 'interface', where the decision to warn the communities is taken at the national level, and the warning and evacuation decisions are conveyed and officially issued to national and local level organisations. This study is an analysis of the interface mechanism of tsunami early warning system, exploring its dynamics and how it can be improved based on the socio-economic and political context. After developing a conceptual framework, the two case studies of Indonesian and Sri Lankan early warning systems were used to understand the current state of the interface. They were evaluated against the concepts within the framework and recommendations were presented to address the existing shortcomings and to improve the operationalisation. As a theoretical contribution, the original conceptual framework was also expanded and improved using the findings from the case studies.

The impact of centralised approach to road reconstruction in post conflict Sri Lanka

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Soon after the end of the protracted ethnic conflict in Sri Lanka in 2009, the government has undertaken a grand scale physical reconstruction process, especially focusing on rebuilding the destroyed road infrastructure. Although the restoration of roads was essential for the much-needed economic recovery of the war affected region, the government was under criticism due to the centrality of its implementation and lack of transparency. On the other hand, there was less attention to political reconciliation and to address the grievances of communities affected by the conflict. As a part of a doctoral study that focused on analysing the consequences of road reconstruction intervention in Sri Lanka, the impact of government's centralised approach to road reconstruction is presented in this paper. The data was collected using 3 divisional secretariats as case studies and analysed using the thematic analysis. The results revealed that the centralised approach used by the Sri Lankan government created inequalities and increased feelings of mistrust, while creating corruption and rent seeking behaviours. Lack of community participation has resulted an increased division among communities and unrest within them. The government has also failed to build capacities at local and national level, and the lack of a reconstruction strategy failed to create links between the physical reconstruction and long-term peace and stability of the country.

Updated digital methodology for Vs_30 estimation – a practical approach

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Due to the necessity of Vs_30 determination (a necessary parameter for many software programs for seismic hazard assessment) for the large cities (between 10 000 and 2 000 000 inhabitants) in Bulgaria a new approach is suggested. It has practical direction considering the difficulties of the Vs_30 estimation in the case of urban settlements. Several methods for Vs_30 determination are developed: in-situ measurements by seismic methods (seismic profiling – Vp, Vs, borehole seismics), liquefaction potential assessment (level of underground waters, densitometry); laboratory methods (penetration tests, density, modules of elasticity, etc.); geological layers analysis and summarization, age of geology formation, etc. The summarized approach includes the following steps: - The investigated site is represented by a polygon. - Dense network of longitudinal and latitudinal lines (in different scales) formed the grid. - The attribution to each sell of the grid the two values of Vs_30 (the minimal and the maximal). - Map and excel table creation formed the date base. - Explanatory notes considering the liquefaction potential, the landslide potential and the possible modification of the amplitudes and velocities of S waves due to the different hardness of the ground. As additional information the DEM of the area is attached.

Identification of Capacity Gaps among Higher Education Institutions in Asia when Developing Multi-Hazard Early Warnings for Resilience

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The link between resilience and sustainable development has been recognized by many researchers and practitioners. Hence, making societies resilient is important when achieving sustainable development. Because, resilient societies have the ability to survive in any challenges created by natural or manmade phenomena. Natural disasters have been frequently reported with significant magnitudes across the world. Hence, policy makers and practitioners look for effective and efficient resilience mechanisms to minimize disaster risks and enhance resilience among communities at risks. Multi-hazard early warnings are one such strategies that can enhance resilience and reduce disaster risks. Recent incidents in Asia repeatedly highlighted the necessity of effective multi hazard early warnings due to increasing frequency of hazards in the region. However, development and operation of a comprehensive multi-hazard early warning system is a challenge in Asia. Studies found that many of these challenges can be addressed through involvement of higher education institutions within these initiatives. Their contribution through knowledge creation, raising awareness and education and provisioning of advocacy towards evidence based policy making can be incorporated in developing and operating resilience strategies. Hence, higher education institutions are identified as an important stakeholder for achieving resilient society through the development and operation of multi-hazard early warnings. Objective: Nevertheless, higher education institutions, particularly in Asia, face many capacity gaps when delivering their objectives. In order to address these challenges, capacity gaps among higher education institutions to be identified. Hence, this study aimed to identify capacity gaps among higher education institutions in Asia for developing effective multi-hazard early warnings towards disaster resilience. Methods: Hence, this study conducted a survey among experts who involve in disaster risk reduction and early warning systems in Asia. The survey was conducted as an online questionnaire survey consisted with opened and closed ended questions. Survey results were analysed using content analysis. Results: The survey results revealed the challenges or capacity gaps faced by higher education institutions in Asia specially when developing and operating multi-hazard early warnings. The identified capacity gaps are: funding and resource constraints, lack of political and policy support, lack of self-interest and awareness, lack of information, lack of coordination, knowledge gap and communication barriers.

Investigation of the Systematic Behaviour of Critical Infrastructures over Floods on Economic Loss Determination

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Floods if not properly managed can make destruction to the lives and properties of the vulnerable communities with a series of cascading catastrophic events. During recent past, the frequency of floods has been increasing at an alarming stage causing huge impacts to the well being of the affected communities. Economic loss due to a disaster is a significant parameter of determining the economic growth of a country. Considering the past experiences, flood damages and losses have disturbed highly on economic growth of the countries. The flood damages causing on Critical Infrastructure systems affect on a bigger portion of the economic loss. Hence, to enhance the resilience on Critical Infrastructure systems to flood hazards, proper risk identification and risk assessment models needs to be developed. In order to capture the systematic behaviour of the Critical Infrastructures, System Dynamic approach can be used. Through this approach, the dependencies and interdependencies of each Critical Infrastructures can be detected and modelled. Under this research study, system based approach integrated with Causal Loop Diagrams were used which is mainly considered as a qualitative approach of system thinking and analyzing. The Causal Loop Diagrams were considered here mainly to visualize the system behaviour of Critical Infrastructure systems in flood incidents, which at the end triggers for the economic loss of the country. A System Dynamic Modelling software was used under the study to develop and illustrate the behaviour of the impact of each selected Critical Infrastructure system with the economic loss parameter. The developed Causal Loop Diagrams finally interpret the combined relationship among the Critical Infrastructure systems in a holistic view which can be used to interpret the direct and indirect impacts of each system failures due to floods.



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Transport and Urban Space

Understanding shared bicycle use in Southern European island cities: insights from Limassol, Cyprus

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The 21st century has seen a cycling renaissance across Europe with many cities moving away from the car-centric infrastructure, urban design and planning policies prevalent since the 1950s. Southern European island cities, which exhibit certain characteristics considered as barriers to cycling, such as hot summers and high humidity, hilliness, and car-oriented culture and infrastructure however, have been lagging behind in this resurgence of cycling. Despite this, bicycle sharing systems (BSS) and policies promoting cycling and sustainable urban mobility have emerged in this region too. A multiple-case study approach is used to understand the introduction and use of the BSS in Limassol (Cyprus), Las Palmas de Gran Canaria (Spain) and the conurbation around Valletta (Malta). This research draws upon socio-ecological models used to understand active travel behaviour, including individual factors, social environment factors, and objective and perceived physical environment factors, as well as the policy environment shaping these. The influence of these factors on BSS use is assessed through analysis of BSS trip data and self-reported usage data from a BSS user survey. This paper presents a comprehensive framework for understanding BSS travel behaviour, as well as the first results from data collection and analysis in Limassol.

Social inequalities in a car dominated built environment – the case study of Malta's transport system

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The built environment is increasingly threatened by the ever growing demands for private mobility. This in turn is responsible for high costs of infrastructure, congestion, accidents, pollution and noise. Similar trends are observed also in small island states where economic development is translated in more car travel. The islands of Malta have been experiencing rapid economic and population growth since the 1990s. There has also been an increase in urban development, an increase in car ownership and use, and heavy investment in road infrastructure. As a result, in the last decade Malta has undergone urban land use intensification and external costs of transport amounting to 4% of the GDP. Regardless of this, there is increasing pressure on local and national governments to further provide space for the car in terms of roads and parking infrastructure. Despite Government's commitment towards a more sustainable transport system in 2016, with the publication of a Masterplan for 2025 and a long term transport strategy for 2050, the issues related to social inequalities are dismissed in what has become a discriminatory transport system and exclusionary built environment aimed at providing solely for the car. This paper aims to highlight these inequalities by looking at key indicators such as accidents, household expenditure on transport, access to car and urban space distribution. This will demonstrate how policies differ from realities of infrastructure development and how inequalities burden societies and urban environments. The study highlights growing concerns over the current political agenda of providing more roads for cars without any evident or perceivable plans in support of other, more environmentally and socially acceptable, forms of transport. It also sets a research agenda into issues related to inequalities, transport and built environment in Malta and other island states.

Utilizing OpenStreetMap data to measure and compare pedestrian streets length in 992 cities around the world

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Pedestrian or car-free streets can powerfully produce multiple benefits for urban quality of life, sustainability, and public health. However, few studies have quantified the length of pedestrian streets in cities throughout the world. This paper uses OpenStreetMap (OSM) data and combines the EU and OECD definition of cities to create comparable global indicators concerning the length of pedestrian streets. Our method combines OSM data queries and spatial analysis techniques in R. We use only the pedestrian tag due to serious inconsistencies observed in other walking-related OSM annotations. The results reveal a chasm in car-free development mainly between Southern and Western European cities and their peers in other continents. Since the latter further underlines clear differences in sustainable urban and transport planning cultures around the world, policy analysts and decision-makers can use these findings to support data-driven car-free urban planning and alleviate the detrimental effects of car traffic on the environment and human health.

Sustainable mobility and climate change mitigation - a framework for developing low-carbon land transport policies

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Transport, one of the most important socio-economic processes of urban life, has become locked into an unsustainable form. The dependence on carbon-based fuels makes the sector one of the highest CO_2 emitters. Despite this, transport has generally taken a low profile when it comes to emission reduction and could contribute more to climate change mitigation. This paper reports on a methodological framework that has been developed to formulate policies aimed towards the transition to low-carbon hence more sustainable mobility. The analysis builds on the theory of social practices as the underlying theoretical framework. Within this framework, transport can be explored as a socio-economic system embedded within the larger societal processes. Hence, from this perspective mobility becomes a consequence of the routines of everyday life. The framework also allows an investigation of how mobility practices are sequenced and interlocked with other social practices and how the sequence and spatial-temporal characteristics of these practices interact with and influence transport choices. This insight therefore means that a shift towards more sustainable mobility requires policy configurations that are aimed at reconfiguring both mobility and non-mobility practices of everyday life. When dealing with climate policies in transport increasing importance is being placed on the need to look at the longer-term future as many measures take time to be effective, and trend-breaking changes cannot be achieved within short-time frames. Backcasting scenario approaches are one type of empirical research technique which has been found to be promising when looking at challenging long-term futures. This paper demonstrates how a backcasting approach can help develop low-carbon transport futures. While taking Malta as a case study, it presents a mixed methodological approach which starts with the collection of information about the current trends and mobility practices. It then goes on to demonstrate how a participatory approach involving different stakeholders can be used to formulate visions of alternative, more sustainable futures and how these alternative scenarios can help in reducing CO_2 emissions from transport. Lastly, it provides a participatory framework which also relies on stakeholder interaction and social learning and through which policy pathways towards more sustainable mobility can be formulated.

Green Travel Plans for Workplaces - Incentives for Modal Shift in the Maltese Public Sector

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In line with the 2050 National Transport Strategy and the 2025 National Transport Master Plan, the Maltese Government is promoting initiatives to encourage modal shift. The Ministry for Transport, Infrastructure and Capital Projects (MTIP) is conducting a pilot project with the primary objective to introduce and promote sustainable modes of travel amongst its employees and encouraging them to use more environmentally friendly forms of transport instead of using their own car. As part of this project a user survey was carried out to establish the current modes of transport used for the daily commute and to determine the users' willingness to shift to more sustainable modes of transport. This paper gives an overview of commuter behaviour and the reasons for their propensity to shift to greener modes of transport. At the time of the survey, 78% of respondents used the private car to commute, whilst around 10% used the bus. Employees are most willing to shift to an electric vehicle and are least interested in bicycle sharing initiatives. Based on the survey findings the MTIP is currently formulating a set of incentives, forming part of a Green Travel Plan, which shall be piloted at a Ministry level and which may later be adopted across the Maltese Public Sector.

Vehicle to Everything Communications in Support of Bicycle Commuting

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Bicycle commuting is considered as one of the travel modes that foster sustainability. A number of studies strongly indicate that uptake in bicycle commuting is directly related to physical health and safety. For example vehicles passing too closely at speed reduces interest in cycling. Indeed bicycle commuting increases in municipalities that are committed to Vision Zero, where speed limits are lowered and enforced and where cycling paths offer segregation from higher speed roads. In this paper we will discuss how low-latency vehicle to everything (V2x) wireless radio technology can evolve to provide an alternative to the physically segregated path, rendering urban connector and inter-town roads safer for cycling. In the process, we define the soft speed limit, the temporal segregated cycling path, and discuss privacy and data issues in both ad-hoc local networks and legacy networks. We compare the V2x-based system to technology currently under development in so far as to how effective each technology is in encouraging bicycle commuting. We end the paper with a discussion on challenges and opportunities the V2x-based system brings about.

Streets, stress and society: the impacts of the urban environment and transport on the Maltese population's mental well-being

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The development of sustainable urban communities is not solely based on economic and environmental sustainability but also includes aspects of social sustainability and resilience. This ensures that people within urban areas are positively impacted by their environment and their well-being is safeguarded. This research focuses on understanding the link between the urban environment and the Maltese population's mental well-being by using the case study of Birkirkara. Using questionnaire surveys and street observations, the main urban stressors experienced by Birkirkara residents will be investigated. The urban stressors are identified through an extensive literature review and then studied in the context of the case study area. Variations depending on the transport mode used will also be analysed. Results from the questionnaire surveys will be correlated with the features observed from the physical environment through a street quality checklist also developed through the literature. The findings provide a useful input for future studies, policy-making and urban planning to support the implementation of sustainable development measures in urban areas, that positively impact the population's mental well-being.

Understanding the role of information and its influence on decision-making for sustainable mobility - a preliminary study

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Awareness of a car's impact on the environment can make people conscious about the effects of their behaviour and encourage them to engage in sustainable mobility. This paper presents a preliminary study that aims to reveal how information about the value of CO_2 emissions from cars influences people's decisions. The study adopted a qualitative approach. Fifty semi-structured interviews were conducted between October and December 2018. Snowball sampling was used to recruit the interviewees. The two main questions involved a hypothetical scenario with different modes of transport and information about emissions, and the number of trees needed to counterbalance the emissions produced by a car. The interviewees were then expected to discuss their preferences and reveal their feelings. The interviews were transcribed, and a thematic analysis was performed. The findings reveal that when the absolute amounts of CO_2 emissions were provided, the interviewees were unable to gauge their meaning, thus making that information useless. On the other hand, when the number of trees needed to counterbalance the CO_2 emissions was presented, the interviewees had a much better understanding of the negative impact. This information was more effective, and interviewees stated that they would consider using alternative modes to the car more seriously. The concluding section of the paper includes a brief discussion and suggestions, based on the preliminary results, for transport policy and planners. Further research on this topic, based on a quantitative study is also proposed.

Climate Change Vulnerability Ranking of Coastal Roads in Malta using Multi-Criteria Methods

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The ranking of coastal roads according to their vulnerability to climate change is a complex issue. In order to increase the quality of life and community sustainability, the environmental and social sustainability of coastal roads must also be considered. Indicators of vulnerability are profiled, on the IPCC-based vulnerability concept and defined as a function of Climate Exposure, Sensitivity and Adaptive Capacity. These dimensions need to be considered during the ranking process and can be modelled as a Multiple Criteria Decision Making (MCDM) problem. This study proposes an approach which integrates the results of different MCDM methods to provide a ranking model for climate change vulnerability of coastal roads in Malta. This approach combines four objective weighting methods made up of eleven climate change vulnerability indicators and applies them to rank the climate change vulnerability of six coastal roads using three MCDM methods. The results indicate different rankings. Following this initial phase two other MCDM methods were used to provide a definitive ranking. The results indicate that the proposed approach can integrate the inconsistent evaluation results of different MCDM methods and produce a coherent ranking of climate change vulnerability of coastal roads.

The Relationship between The Constructivist Density Of The Urban fabric and The Solar Radiation within The Urban canyon

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The constructivist density of the urban fabric is considered as main controller in the amount of the solar radiations within the urban canyons. The methodology is experience in order to raise the real values of the air, outer wall and ground temperature every two hours each three consecutive days, also the comparison of the values temperatures obtained by the measurement points positioned via the three types of urban canyons with three different relationship between L/W ($L \geq 2w$ - $L = w$ - $L \leq 0.5w$), according to the direction: (North-east / South-west). Conclusion, the values difference of the temperatures between the three types, where was the urban canyon type ($L \geq 2W$) is the less exposed to solar thermal radiation and the lowest temperature. Thus turns out the effect of the constructivist density of the urban fabric by the relationship between L and W to protect the outdoor spaces urban, this is very important for desert cities.

Investigating the Contribution to Sustainable Development of Public Open Spaces in the Maltese Urban Conurbation

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The need to strive for sustainable development and mitigate or adapt to climate change are increasingly at the forefront when planning for and managing urban concentrations. Urban design is considered a key player as it has substantial potential to affect the various dimensions of urban form. The design of urban open spaces is one area within the dimensions of urban form which is increasingly recognized for its importance in improving the sustainability of built environments and responding to climate change. A review of Maltese policy and publications reveals the poor quality of open spaces in Malta. A number of trends support the need to develop research on the planning and design of open spaces in Malta. These trends include: the particularities of Malta´s scale; development pressures; policy orientation; governance; climatic conditions; and mobility and traffic congestion. The suggestion is made that a 'gap' exists in relation to the planning and design of urban open spaces in Malta. This problem is being addressed by an on-going PhD research being carried out at the University of Malta. The research´s aim is to investigate planning policy and the design of public urban open spaces in Malta and use the outcomes to develop proposals, to improve their contribution to sustainable development. Based on this, the objectives and research questions are also defined. The research adopts a mixed methods approach using both quantitative and qualitative data collection techniques. It also adopts a two phase methodology where the initial findings are further investigated using a second round of data collection resulting in a ´Mixed Method Exploratory Sequential Approach Using a Single City Case Study´. One of the first data collection techniques is in the form of a physical survey of public open spaces within Malta´s urban conurbation. The purpose is to answer one of the research´s objectives this being: to further understand the contribution of Malta´s urban public open spaces to sustainable development and identify critical design themes specific to the Maltese context. The survey was carried out on 42 public open spaces in two areas in Malta´s urban conurbation incorporating eight different localities. The spaces included a range of typologies, these being: Gardens / Parks; Children´s Playgrounds; Civic Squares / Pjazzas; Coastal Promenades; Natural / Semi-natural Areas; Amenity Green Space; and Water Bodies. A statistical and thematic analysis of the data collected was carried out and the paper will present some of the key initial findings.



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Sustainability Assessment Tools

EPBD cost-optimal analysis for non-residential buildings in Malta

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The Energy Performance of Buildings Directive (EPBD) 2010/31/EU requires that EU Member States to calculate the cost-optimal levels of minimum energy performance requirements for new buildings and buildings that undergo major renovation. The European Commission Delegated Regulation (EU) No 244/2012 and accompanying Guidelines 2012/C 115/01 establish a comparative methodology with regards to number of reference buildings for each building category, number of energy efficiency measures to be implemented in the study and the minimum level of cost analysis that is required. Quite often, such an approach yields limited information, which would satisfy the Directive's exigencies in terms of cost-optimality, but would not necessarily provide a full picture of the possible solutions available. This paper explains the innovative approach that was adopted in the Malta cost-optimal studies of 2018, whereby a two-stage optimisation exercise was carried out. The aim of this approach was to reduce the number of iterations, without sacrificing on the final accuracy of the results. This approach was adapted from evidence-based results reported in peer-reviewed literature. Optimisation Stage 1 found the optimal combinations (packages) of the design variables (in terms of building envelope, shading and fenestration), which influence the energy demand for space heating, space cooling and mechanical ventilation for each reference buildings. Representative points that were carefully chosen along the pareto optimal combination of measures resulting from stage 1 were then combined with different measures for mechanical space heating and cooling, domestic hot water, lighting and renewable energy measures to identify the cost optimal measures and define the cost-optimal range in terms of primary energy performance (kWh/m2/year) for each reference building. For all building categories, given Malta's mild Mediterranean climate, the cost-optimal range was found to be much more sensitive to upgrades in active measures versus improvements in building envelope U-value measures of opaque elements. However, with respect to passive measures, shading of exposed glazing in a range of orientations was found to play an important role in improving the energy performance of buildings and was found to be cost-optimal for reference buildings with large window-to-wall ratios. When considering active systems, for all new building categories, high efficiency space heating and cooling equipment was generally found to be cost-optimal.

Furthermore, DHW heat pumps/solar water heaters were also found to be cost-optimal for all buildings having a demand for domestic hot water including restaurants, sports complexes, hotels and homes for the elderly. The installation of roof-top photovoltaics (PVs) was also found to be cost-optimal for all building categories for which PVs were considered. Given the diverse activities carried out by the different building categories, the resulting cost-optimal range for new buildings varied from 318-397 kWh/m2/year for school buildings to 786-841 kWh/m2/year for hotel buildings. The cost-optimal energy performance benchmarks resulted to be higher for buildings undergoing major renovation, when compared to new buildings of the same geometry, characteristics and size. The results emanating from the cost-optimal studies, with regards to elemental (building envelope and technical building systems) and the overall energy performance benchmark will guide the next upgrade of Technical Document F for statutory NZEB building performance in Malta.

Towards improved building inspection and diagnosis in Spain

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Actions on the existing building stock, aimed at achieving its maintenance and renovation, contribute to reach the EU targets. To start with, enhancing the knowledge of the buildings to undergone renovation is proposed as a mean to facilitate its management. By considering that the use of smart technologies can help in capturing and storing knowledge of the buildings, the Spanish ROBIM project focuses on the development of a new inspection technology. This paper presents results of a two-round Delphi consultation, part of the ROBIM project, which was conducted to guide the decision-making process in the development of the smart technology, and to identify current experts' priorities in the Spanish renovation and maintenance market, being the later the focus of the present paper. Within this Delphi, 52 agents participated at the end of 2017, rating on a 5-Point Likert-type scale relevant statement to explore such priorities. The 28 final statements analysed, categorized within four domains (Techniques and Technologies, Information Management, Auxiliary Means and Boundary Conditions), and achieved a high consensus rate among experts. The analysis of the different levels of consensus enables the identification of priorities for the Spanish building renovation and maintenance market and issues to be tackled.

Assessing the load shifting potential in buildings – Application of a methodology for the Smart Readiness Indicator on a theoretical use case in the city of Vienna

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The Energy Performance of Buildings Directives (EPBD) is one of the key documents defining the guidelines for the European Member States related to energy efficiency in buildings. With the third revision in 2018, further measures were added to the EPBD with the goal to increasingly improve the quality of the European built environment. In addition to applying minimum standards for energy efficiency and the integration of renewable energy systems in buildings, the new version foresees that a Smart Readiness Indicator (SRI) must be applied in order to assess the capacity of buildings to use information and communication technology (ICT) in the interaction with the user and the grid with the goal of increased efficiency. The European Commission has already presented a study with a proposal for the SRI consisting of a rather qualitative assessment. In this paper a previously developed methodology comprising of a quantitative approach, that assesses the load shifting potential of buildings, is applied on a theoretical use case in the city of Vienna. An exemplary block of a Viennese district, consisting of a mix of different types of buildings characteristic for the inner city, is used to validate the methodology on multitude of buildings. The goal is to evaluate, how the quantitative approach can be applied for the analysis of existing buildings as well as different refurbishment scenarios for these buildings. The results show that a quantitative methodology for the SRI can provide an assessment for current and future scenarios for load shifting potentials of buildings. This approach facilitates the assessment of whole building districts or cities in terms of their overall capacity to store and dispatch energy over a certain period of time. In addition to providing a useful indicator for the Energy Performance Certificate (EPC), the results could also support energy providers in assessing the overall load shifting potential of the built environment of whole districts or cities.

Sustainability Assessment Framework for the Urban Environment: Application of CESBA Tool at the University of Malta Campus

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The CESBA Med Interreg Med Project has the objective of reinforcing the capacities of public administrations through the provision of a CESBA Med trans-national methodology and set of tools to promote Sustainable Mediterranean Cities. This would support the optimization of energy planning measures which take into consideration both the building and urban scale. Through this methodology, the objective is to reinforce the capacity of public building stock owners and to improve the quality of energy efficiency plans for public buildings. The CESBA Med tool was developed as a common sustainability assessment framework at the Building Scale and at the Urban Scale. The tool is presented as an innovative decision making process and is organised in different segments for the assessment of the urban area. The generic framework is based on a multi-criteria analysis methodology for assessing sustainability of the built environment. The framework is organized through Issues (7 Issues: macro-themes chosen and recognised as relevant for assessing the sustainability of a building or urban area, that is a built urban system, economic structure and value, energy, atmospheric emissions, non-renewable resources, environment and social aspects); Categories (23 Categoris: particular aspect pertaining to a specific issue, that is Urban Structure and Form); Criteria (178 Criteria: specific aspect of the relative category representing the basic assessment entries used to characterize each building or urban area). Each criterion is associated to an indicator referring to the method which allows for the characterisation of performance. The generic framework was contextualized to produce Regional Tools through the selection of active criteria, the definition of benchmarks for each criterion and the weight assignment to criteria. The sustainability assessment score is computed through a mathematical procedure which is based on Characterization, Normalization and Aggregation. The tool was applied at test sites in the Mediterranean region, including the University of Malta main Campus for the assessment of sustainability at the building and urban scales. The outcomes of the assessment are presented, supporting the development of the CESBA Med Tool for sustainability assessment of Mediterranean Cities.

Prioritizing Energy Efficiency Measures in Maltese Restaurants

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The 2018 Energy Performance of Buildings Directive (EU) 2018/844, focuses on building energy renovation. With the increase in tourists and working opportunities in Malta, the restaurants' sector is experiencing a business boom. Despite this sector being a major energy consumer, the energy performance of restaurants in Malta has been given little attention. This paper investigates the energy performance of four representative restaurants in Malta. Refrigeration accounted for the highest share of 40% electricity consumption, followed by kitchen exhaust ventilation, domestic hot water and space cooling, which accounted for about 50%, while lighting consumed only 6%. Energy saving potential was primarily identified for refrigeration, water heating and air-conditioning. Although, the fuel sources used for cooking equipment accounted for more than 50% of the overall energy used in these restaurants, electricity is the fuel of primary concern as on average it contributes to 70% of total carbon emissions and results in the highest operational cost. The total potential of carbon emission savings was found to be 17%, when the recommended energy efficiency measures are applied. A benchmark of 14.51 kWh primary energy per person served was established for energy-efficient restaurants. This paper provides evidence-based results that are useful for policy makers to introduce fiscal incentives to support the transition of Maltese restaurants to nearly-zero energy status.



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Education for Sustainable Development

The Effectiveness of the EduChange Project in increasing knowledge, Values and Attitudes towards Climate Change

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The EduChange project is led by a consortium of four universities and its main focus is to develop innovative ways of teaching about Climate Change through water related issues, utilising innovative place-based education and blended learning. Through EduChange, trainee teachers are encouraged to develop creative learning environments in which, students create knowledge and learning experiences together. EduChange is co-funded by the Erasmus+ Programme of the European Union. Research on projects that aim to influence awareness and behaviour towards climate change has been published globally, but studies on the effectiveness of interuniversity led projects that focus on pedagogy are however limited. This study aims to shed light on the knowledge, values and attitudes of student teachers towards climate change and the extent to which the EduChange project can be a vehicle for change. One student cohort composed of students coming from Malta, Norway, the Netherlands and the Czech Republic were selected for this study. A mixed method longitudinal approach was adopted and entailed the collection of data from both qualitative and quantitative methods. The data was collected two weeks before the fieldwork sessions through interviews and questionnaires and again two weeks after the fieldwork sessions with the same exact methodology. The pre intervention and the post intervention data were then analysed and compared. The study shows that EduChange had a positive effect on the knowledge and awareness of student teachers about climate change issues. Moreover, results show that the various activities had different rates of success in different contexts. In response to these findings, a number of recommendations and a list of possible activities are drawn up to further enhance the effectiveness of the project and to infuse ESD principles in climate change education.

From words to action: Empowering young people for sustainability

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Education has always been earmarked as one of the major tools required to achieve sustainability. Since the Tbilisi Conference in 1977, the main challenge to achieve the aims of Education for Sustainable Development (at the time referred to as Environmental Education) was to promote a change in educational structures so as to empower learners and go beyond awareness and move into active participation in finding solutions. However, formal educational institutions have maintained traditional structures and practices that have resisted change. The paper shares the lessons learnt from the implementation of the Eco-Schools programme in the Maltese compulsory educational systems. The Eco-Schools experience provided the Centre for Environmental Education & Research (University of Malta) with an opportunity to partner with an NGO and provide Education for Sustainable Development in the community interface). Moreover, Eco-Schools proved to be a flexible programme that adapts to the needs of the school and provides an opportunity to address real and relevant sustainability issues. The paper also highlights the impact the Eco-Schools programme had on the holistic development of learners and provides recommendations on how the programme could be used to enhance autonomous learning and responsible citizenship.

Global Education – An Introductory Course to Educators in Malta

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The Maastricht Declaration on Global Education claims that an education comprehensive of the global dimension is a call for education equity as it broadens the understanding of regional disparity and awakens the need to address social inequalities. The underlying principles of Global Education are congruent with the objectives of Education for Sustainable Development. This paper accounts for and appraises a training course organised by the Science Centre, Directorate for Learning and Assessment Programmes, Ministry for Education and Employment, Malta for educators working within the Maltese education system. The course was part of the Global Education Network Europe (GENE) strategy for Malta and it was designed for members of the schools' senior management teams and educators working in any cycle of the education system. The global dimension as discussed in the continuous professional development course for educators was unfolded by considering issues and processes through a relational approach of both the socio-political dimension and the bio-physical process to highlight the complex dynamic global systems that lead to and reflect regional disparity. The complexity of case studies and issues discussed at different scales through the enquiry approach was intended to point out how the local is an agency to the global issues to which there is no simple solution. This approach was intended to lead participants to understand the importance of responsible global citizenship as a means to address social inequalities and address the sustainable goals. Social inequalities are also the result of educational barriers and the role of the educator is not limited to pointing out these inequalities but also to try to address them. The course provided practical guidelines on how educators may try to break these barriers and how to include the global dimension in the schools' routine and curriculum. The discussions related to the practical transfer of the theory discussed during the CPD to practices in school served as the baseline of the evaluation of the course itself that was eventually complemented by a focus group discussion and questionnaire.

Early Stage Retrofit Stakeholder Engagement; Enhancing Higher Education Project Success

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In the case of higher education facilities, many institutions strive to ensure that facilities are high quality, and portray an image of sustainability and global responsibility. Furthermore, to enable high quality research and teaching outputs from universities, a good quality working environment is vital to productivity and employer reputation. In this sense, ageing building stocks needs to be modernised to ensure environmental performance and to respond to the changing requirements of teaching and learning. Although superficially it may seem a straightforward pathway to promote the green campaign via buildings, in higher education complexity can be added in various ways; differing client requirements, democratic decision-making, budget restrictions and project schedules. Some universities choose to involve end users and stakeholders in a central manner to a project, which can cause information overload and protracted timescales, whilst others select a route of minimal end user involvement. Using a case study approach, this research looks to highlight key elements of successful early stage retrofit stakeholder engagement. Key case study data collected includes qualitative stakeholder interviews, analysed using textual analysis software, and also occupant comfort questionnaires to assess building usage practices, seasonal comfort variations and quantitative rating of building spaces. Findings highlight that retrofit project end users, require engagement to aid articulation of priorities, along with the utilisation of engagement strategies to promote project buy in. This engagement illuminates key areas of potential conflict of requirements, for example the role of heritage protection versus change, or the contrast between increasing flexibility of space usage and retention of legacy space utilisation practices.

Education for Sustainable Development; Architecture discipline, Bahrain

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The Sustainable development goals SDGs have become a well-recognized and publicized agenda. The United Nations through its various programs has widely promoted the SDGs in developing countries. SDG4.7 addresses education for sustainable development and global citizenship; stating that " all learners acquire knowledge & skills needed to promote sustainable development". The discipline of architecture, as a virtue of its protagonist, impacts the built environment through the design of spaces, buildings, and cities. This paper address education for sustainable development in Bahrain. First by displaying the country's agenda in relation to Sustainable Developments in Education in general, and second by specifically listing higher education institutes efforts in architectural disciplines through the initiation of sustainable design modules. Finally, to exemplify architecture student visions, several projects will be illustrated relevant to future cities, which address several aspects of sustainable development goals. As the future of cities, and the world as a whole, lies in the hands of the youth, knowledge, and education today is a powerful tool that can reform the future, and architects, along with other stakeholders, will be responsible for this future.



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Structural Systems

VR-SHM A structural health monitoring tool to assist crack detection using deep learning and virtual reality

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Monitoring concrete surfaces of infrastructures to identify defects at an early stage is paramount to cost-effectively manage structural assets such that preventive measures can be taken to avoid larger infrastructural damages as well as to prevent accidents that might otherwise take place. During concrete inspection, the most sought after defects are cracks as they are the earliest indications of structure degradation. Traditional methods of crack detection rely on on-site visual monitoring which is time consuming, tedious and expensive, human-subjective and exposes inspectors to possible hazardous environments. To mitigate this, a number of computer vision-based crack detection techniques were developed to automate the crack detection process. Nevertheless, these techniques have not yet replaced visual inspection. This work aims to facilitate regular inspection of concrete structures and speed up the assessment of crack identification by providing a structural health monitoring tool to assist crack detection. It identifies cracks automatically through a deep learning architecture and then displays the identified cracks on a 3D model which can then be viewed using Virtual Reality (VR) for better contextualisation, enabling the identified defects to be further analysed remotely. The proposed system contributes 1) a crack detection technique using deep learning 2) 3D reconstruction of the infrastructure and 3) visualisation of detected cracks using VR.

Current density and oxygen depletion in a galvanic pair embedded in concrete

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Chloride ion presence in the pore solution causes corrosion of the rebar in reinforced concrete structures. This corrosion causes rebar expansion which in turn results in the deterioration of the structure thereby effecting its resilience. IC sized sensory systems can be distributed widely around the structure, since they are miniature and very low cost. Given the possibility of obtaining wide sensory coverage with such miniature sensors, it would be possible to detect chloride ion ingress in real time thereby allowing interventions to be carried out in a timely fashion. This would make the structure potentially much more resilient. An IC sized sensory system based on a galvanic pair of electrodes can be used to provide the backbone for such a reliable and responsive system. The galvanic pair sensory system can also be used to provide sufficient current density which would enable it to provide power to the IC itself, apart from acting as the chloride sensory element. The electrochemical reaction occurring in the galvanic pair, consumes oxygen, which would need to be effectively replenished for the reaction to be able to sustain itself. It is therefore imperative to model and study oxygen depletion and replenishing mechanisms in conjunction with current densities which can be sustained by a galvanic pair embedded in concrete. Such studies would then act as the groundwork needed to be able to design and build an effective sensory system. This paper outlines the modelling and analysis carried out to study oxygen depletion with corresponding current densities obtained. This background would enable the establishment of the parameters required for the later design an effective sensor and power supply.

Historic Reinforced Concrete Structures and Infrastructures: diagnosis, repair and monitoring

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Historic reinforced concrete structures represent a large part of the existing buildings and bridges. The inspection and diagnosis of this type of structure is crucial to verify the safety and identify any structural repair, in respect of the historicity and conservation of these buildings and bridges. Considering a large number of inspected structures it was possible to set up a procedure that allows a careful analysis of this type of structure, coming to identify a level of safety with respect to static and seismic loads. The analyses and checks carried out are fundamental for identifying any structural reinforcement. Using advanced technology and innovative materials it is possible to repair the damaged concrete and increase the capacity of the structural elements to resist to static and dynamic loads. The concrete characterization, repair and conservation is fundamental to respect the historicity of this kind of structures. After the these repair works it is very important to guarantee a future control with a structural health monitoring system, that can control in a secure and continuous way the safety of the structures. Modern sensors and control networks can make it possible to verify many important parameters over the years. This procedure that start with diagnosis, goes through structural repair and provide an health monitoring system, will be illustrated following some real cases. The first case concerns an historic thermal power plant built in 1938 in Florence, Italy, and characterized by a reinforced concrete structure that with the chimney reaches a height of 50m and has inside columns with a free height of 17 meters. Some cases of old reinforced concrete structures with low characteristics present on the Maltese territory and reinforced with innovative materials are then illustrated. Regarding the infrastructures we will describe the case of an historic bridge build in 1958 in Florence, Italy, with the project of Italian Engineer Riccardo Morandi. This very delicate infrastructure is studied and monitored with a specific system that can give a real time feedback regarding the health of this historic bridge.

Near-field earthquakes on seismic vulnerability assessment of historical masonry buildings: the case study of the Banloc Castle in Romania

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The recent seismic events have produced a large number of damages and losses, which could be avoided or mitigated by an appropriate preventive analysis oriented towards the seismic risk assessment of urban areas. Romania is an European country with two significant seismic zones, namely Vrancea and Banat. Timisoara is one of the largest cities in Romania. It is located in the seismic area of Banat, which is characterised by shallow earthquakes with depths between 2 and 20 km. For this reason, earthquakes occurred in this Romanian region were distinguished by impulsive and strong vertical accelerations. According to this premise, the current research aim at investigating the influence of the ground motion vertical component on the seismic vulnerability of historical masonry buildings in case of near-field earthquakes. Generally, the earthquake vertical component is mainly characterised by vertically propagating compressive P-waves, which anticipate the occurrence of secondary shear S-waves. In the paper, the Banloc Castle, damaged by the earthquake occurred on December 1991, has been selected as a case study to evaluate the damaging effect due to vertical accelerations. A macro-element model of the historical building has been setup with the 3Muri analysis program, which has allowed to perform non-linear static analyses. The analysis results have shown that the vertical ground motion with high frequency pulses, which gives rise to the cyclic degradation of mechanical characteristics of masonry, significantly reduces the structural performance of the castle.

A novel green reinforcement system for retrofitting existing historical masonry buildings

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Given the high number of masonry buildings on the Italian territory, which was scenario of numerous devastating earthquakes in the last decades, the programming of refurbishment interventions is a pressing need for practitioners and researchers. Thanks to a renewed technique sensitivity towards sustainable interventions, it is evident that recovery techniques to protect the historical heritage could be effectively carried out with innovative green compound materials, such as mortars reinforced with natural fibres. These new systems used to reinforce masonry walls can replace the more expensive and pollutant techniques based on classic composite fibre-reinfoced polymers. In this framework the current paper is placed with the goal to introduce a novel reinforcing system of existing masonry buildings based on lime mortars reinforced with hemp fibres arranged under form of sheets. Firstly, experimental tests from literature on this system have been numerically calibrated using the ABAQUS non-linear numerical code. Subsequently, the fibre-reinforced system has been applied to a masonry wall and FEM parametric analyses have been carried out to find the optimal configuration able to offer the best increase of mechanical properties with the minimum cost. Finally, the reinforcing system found in the previous analysis phase has been used to strengthen an existing historical building. The benefits deriving from using the new natural reinforcing system have been highlighted and the comparison with the common techniques based on fibre-reinforced polymers has been performed.

Easy safety check criteria for beam members of RC frames equipped with full and perforated Steel Plate Shear Walls

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In the present work it has been investigated the use of metal perforated shear panels for seismic retrofitting of existing reinforced concrete (RC) structures. In this context, the use of traditional metal panels, due to the development of diagonal tensile stresses generated on RC structures, often requires expensive and invasive local reinforcement interventions of existing members. Solutions based on low-yield steels and pure aluminium alloys allow to limit the extent of the actions that panels exert on RC beams and columns. An alternative technique is based on the use of steel perforated shear panels which, thanks to the presence of suitably arranged circular holes on the plates, can either eliminate or reduce the aforementioned reinforcing interventions. In the paper, after the development of a FEM model for steel perforated panels calibrated on experimental results, it has been simulated, by using the nonlinear analysis software ABAQUS, the experimental test conducted on a RC structure adequate with metal shear panels within the Italian ILVA-IDEM research project. Subsequently, on this structure it has been evaluated the effectiveness of using perforated panels with different arrangement of holes (diffused or concentrated on edges) in order to reduce the strengthening of RC members. In conclusion, simplified criteria for the design of aforementioned seismic devices have been developed as a function of seismic deficiencies expressed by the existing RC structures examined.

Malta's Heritage in Stone: from Temple Builders to Eurocodes 6/8

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The Maltese archipelago has been inhabited since 3000BC and the evidence of occupation is preserved within the fabric of the cultural built heritage.
Malta's well behaved semi-arid Mediterranean climate resulted in durability for its compact limestone resource. A French study defines a compact stone having a crushing strength lying between $10N/mm^2$ & $40N/mm^2$, a soft stone $<10N/mm^2$, & a hard stone $> 40N/mm^2$.
There is little preservation of structures from the Arab occupation from 870 up to 1090. However the construction methods in vernacular construction used in Malta from this point to the mid-20th Century derive from the methods first introduced at this time. These derived from Byzantium Syria. Some of this early and weak rubble construction was destroyed in the earthquake of 1693. The expertise of the military engineers of the Knights of St. John who began to build Valletta in 1570 was shared with Maltese masons and led to significant structural improvements, with timber introduced.
The British period 1813 – 1964 brought along the Corp of Royal Engineers. Steel joists were introduced and widely utilised in this period, embedded in masonry floor slabs. Building regulations were also introduced in the form of The Police Laws in 1854. The British London Building Regulations prior to the 1948 masonry codes of practice resulted in the construction of regular, 8-storey cellular residential constructions rather than the previous maximum 5 storeys.
The aesthetics together with the reverberation proportions of masonry spaces is introduced. The role of the structural engineer in designing a building is to exercise their numeracy, to consider both the aesthetic proportions and the impact which these have on the reverberation characteristics.
A comparison is drawn between the BS & EC masonry codes with the characteristic strengths for the Maltese limestone masonry building block outlined in the respective codes. The seismic rigidity of the Maltese masonry constructions is further outlined according to EC8. The effect of blast loadings is finally also considered. The rigidity of these regular planned masonry constructions as subjected to low seismic risk is confirmed, however this is not so as when subjected to blast loadings.
An appendix is provided which introduces a calculation for the verification of thin masonry slabs, which was an important Maltese building element up to the mid-1960s. The importance of this structural check becomes necessary, when the building use is to be changed resulting in additional loading.



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Sustainable Regeneration of Cultural Heritage

New Sustainable Acupunctural Strategies to Preserve, Refurbish and Promote the Cultural Heritage: Challenges and Solutions. The Case Study of Bisotun site in Kermanshah (Iran)

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Cultural heritage interpretation as the continuous, integrated, living phenomenon is the core concept of a new paradigm in cultural heritage preservation strategies. This paper aims to provide the proper refurbishment principles in effective intervention in two highlighted monuments in Bisotun Cultural Heritage (BCH), which its central zone inscribed on the world heritage list in 2006. Bisotun have been immortalized thanks to Darius I (521 BCE) inscription and evidencing 30 incredible historical remnants of Iranian civilization. This research was carried out with descriptive-analytic method applied to investigate challenges ahead in sustainable refurbishment of Khosrow bridge and Khosrow palace (600 A.D.). Different innovative solutions employed for each monument to ensure historical values and tackle the issues threaten their integrity. Three multi critical hypotheses are: Regeneration the smart green connection between the bridge and BCH, Designing a linear multi-functional bridge market to link Cham Bottan Village to the Khosrow palace, Refurbishment the historical palace as a public art center for showcasing traditional performances and local productive and agricultural traditions. Due to filling research gaps in this field, survey the data and detailed description of observation and 3D models will be applied. In conclusion action plans have been defined due to preserve long-term benefits.

Field Assessment of Heritage Buildings: A study of the Presidential Palace of San Anton, Malta

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Heritage buildings play a key role in the move towards a more sustainable future, offering great potential in the drive to reduce energy demand. They were designed to incorporate passive environmental strategies common throughout the Mediterranean which, although intended to provide comfort, may be maximised to improve building performance. However, a design team faces considerable challenges in developing interventions for the adaptive reuse of heritage buildings. Proposals must address the complexities of this architectural typology by considering several different aspects, including heritage value, environmental performance, occupant comfort and modern requirements generated by the new use. In Malta, this is compounded by a lack of formal guidelines for pre-design assessment. These would enable design interventions to centre on evidence-based decisions, developed through a structured and comprehensive understanding of the building. This research outlined a best-practice procedure for the assessment of heritage buildings in the Mediterranean region, to be adopted before designing interventions. The strategy has been established as part of a wider ongoing study which seeks to develop an effective framework for the sustainable regeneration of heritage buildings in Malta, with widely applicable principles. It includes a building and occupant surveys, desk study, environmental monitoring and computer simulation. The 17th century Presidential Palace of San Anton, Attard, was used as a case study. The difficulty in balancing conservation principles with the provision of functionality and comfort is clearly exhibited through this building. The complexities of San Anton Palace provided the opportunity to explore the multi-faceted aspects of field investigation within a highly challenging scenario. As a result, the guidelines for formulating an assessment strategy developed through this study are applicable to wide context.

Smart Home as the Platform for the Behavioural Training leading to Sustainability in Historical Home

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The mission of this experiment is to watch human acting in an interior environment. The human acting is considering an energy efficiency of Smart Home. We developed a game design inspired interactive solution for quantification of the behavioural phenomenon. The mission of the experiment is leading to explore a mechanism, which should encourage potential users to fully control Smart Home potential. If the inhabitant treats Smart Home sustainably, the same user is gaining sustainable habits. Our tested Smart Home is an interactive infrastructure situated near UNESCO Cultural Heritage. Naturally, this Smart Home is under areal heritage protection. These defined limits create the experimental environment where we are studying the user's relationship to Smart Home, and the user´s acting causing the need for different spatial configuration. We are exploring a methodology for Smart Home intervention in the preserving area, and the artistic character of the installation as well.

Socio-economic and environmental sustainability of traditional residential units

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Sustainable design is an integral part of contemporary design. It is intrinsically associated with the promotion of quality in a built environment through the premeditated reduction of its impact on the natural environs. This widely applied notion, grounded in diverse definitions of sustainable development, was significantly accentuated in the Brundtland report. Centred around this definition, a number of approaches and indicators were adroitly developed to address the concept of sustainability. These academic contributions fall short of acknowledging the geocultural significance of existing built environments, a time-tested tenet of sustainable development. Based on case-studies emanating from the central Mediterranean, this paper addresses the socio-economic and environmental sustainability of architectural design interventions in sub-standard dwellings, individually or in clusters, located within urban conservation areas. Comprehending and sensitively integrating the nature and qualities of traditional building materials and the physical orientation of these tenements, the resultant interventions created socio-economic, cost-effective holistic solutions. Consciously integrated investment-oriented, heritage sensitive designs indubitably result in the regeneration of the historic urban cores. Such regenerated cores embody the essence of socio-economic, time-proven, sustainable development rather than serving as laboratories of speculation under the guise of 'developments' seemingly satisfying contemporary energy efficient specifications.

Influencing Behavioural Change: An integral measure in the sustainable regeneration of heritage buildings

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The building industry in Malta accounts for approximately 35% of total energy consumption. Occupant behaviour has a considerable impact on energy use in buildings. Therefore, the ability to influence behavioural change is of critical importance in the drive to improve environmental performance. Passive strategies were incorporated in the design of heritage buildings to enable occupants to maximise comfort. This must be coupled with a basic understanding of the function and benefits of these features. Despite playing an important role in this context, data regarding public attitudes and awareness in Malta was not available. As part of a wider study, this research was based on two primary objectives. Firstly, using a structured questionnaire, it aimed to establish public attitudes towards the sustainable regeneration of built heritage in Malta, and assess levels of awareness and knowledge base regarding the benefits of passive environmental design strategies. Secondly, it sought to test the efficacy of a seminar as a method of disseminating information to the public in order to incite positive behavioural change. The results demonstrate that although respondents advocate for increased heritage conservation, this is based on an appreciation for the aesthetic and atmosphere, and traditional buildings are perceived as providing inadequate comfort. Furthermore, despite having some awareness of passive environmental strategies, participants do not associate these with historic architecture. However, the seminar was found to have triggered a positive response. The study concluded that systematic dissemination of information is an important aspect of a national strategy supporting the sustainable regeneration of built heritage through behavioural change, and that a seminar may be used effectively as an implementation tool.

The Miracle of Concrete has Befallen; reconciling historic concrete technical repairs with the philosophical conservation principles

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Through the passing of time, there have been many studies and approaches towards conserving virtually every building material possible. This, however, is with the exception of new, scientifically created materials, like concrete. The need for repair and conservation in this material only started to arise in the middle of last century. According to several scholars, concrete is the most important construction material in the modern age. Its use has been constantly on the rise since the late 19th century, when reinforced concrete was developed. By the end of the 20th, several architects and engineers had exploited its potential, leaving behind a legacy of extraordinary structures, an aging legacy that needs to be well looked after. Concrete repair is still a subject of several disagreements. The world of conservation still lacks common and well-established approaches as well as well-versed practitioners in the subject of concrete. The principle research question behind this study is whether there is a common ground in the conservation practise, between the moral principles of conservation philosophies and the diverse repair techniques, bound by material science. This study should also facilitate to understand whether conventional and common repairs abide by conservation principles and to what extent can a principle be bent to fit a practise. This study took a qualitative data collection approach. This allows the researcher to collect the subjective understanding of the interviewee. The interviews aim to gather valid information that should be significant in answering the research questions posed by the researcher. As this study is drawing to an end, some interesting results are already emerging. The views and ideologies of different industries, which were previously though to be very different, are seen to converge and run in parallel. Whilst the literature focuses on this discrepancy, the study is challenging it, and bridging these gaps. The final results are to be submitted by mid-September, but they should offer a reconciling insight for the two industries.



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Sustainable Buildings

Sustainable refurbishment for large panels prefabricated collective houses - archıtectural and structural solutions

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In Romania, over 71% of existing building stock in urban areas is composed of collective large panels prefabricated houses. As a result of using the reinforced concrete diaphragms structural system, the interior design remains frozen in these units. From an architectural and livable area point of view, these units concern special attention regarding both the refurbishment of the envelope and interior space design. Thereby, the necessity of large openings in the vertical diaphragms are highlighted from an architectural point of view that allows redesigning the rigid partitioned interior and also provides multiple options in terms of interior furnishing. The paper presents the opportunities highlighted by interior design and the capacity of space redesign if some interior concrete panels are removed and replaced with steel frames. The paper also presents the results of structural analyses conducted on the buildings before and after interventions. A sample of test results obtained for the models simulating the insertion of steel framing units into the existing concrete panels' structures are also presented.

SU.PR.I.M.: a new building element for prefabricated sustainable constructions

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The paper concerns the development of an innovative building module with advanced thermophysical and mechanical properties that will act as a bearing element and/or as an internal partition wall in prefabricated residential buildings. This new building module will satisfy high requirements with regard to its operation and performance. Specifically, it will be able:

• To bear and deliver safely all the imposed building loads.
• To display advanced energy performance, contributing to the formation of a building with almost zero energy consumption.
• To demonstrate excellent hygrothermal behavior, by preventing the surface and interstitial water vapor condensation, as well as minimizing the impacts from rain.
• To provide acoustic insulation protection.
• To have resistance against fire actions.
• To exhibit an advanced environmental performance in order to minimize its environmental footprint during its life-cycle.

The high performances of the building element are ensured by the proper configuration and assembly of the layers that compose it, and are verified through analytical and experimental studies, measurements at qualified laboratories, monitoring of the indoor and ambient conditions in an experimental chamber that will be especially constructed for this purpose. In this way, the development of a multifunctional building element is achieved, that, when repeated, it can formulate a building envelope with high structural, hygrothermal, energy, acoustic, fire and environmental performance at the minimum possible time and cost. The accomplishment of this objective offers multiple benefits to the business sector and the research community, but also to the society, as it promotes the construction of buildings with advanced energy and environmental performance that can mitigate and adapt to the climate change impacts.

Alternative façade systems for adaptable buildings towards climate change

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The building industry has a high energy consumption, which results in natural resource depletion, land use, ecosystem degradation, atmospheric pollution, and many other environmental impacts. The intense urbanization process Romania has known during the industrialization period of the 1960-70s led to an exponential shortage in urban housing. Like other countries, but more specifically to the former Eastern block, Romanian state-financed collective dwellings were erected starting from standardized projects of Reinforced Concrete Large Prefabricated Panels (RCLPP) blocks of flats, generating nowadays a repetitive built stock of identical buildings and several apartment types, widespread throughout the entire country. These buildings currently house 60% of the urban population of Romania that own 96% of the apartments, as opposed to the European trends regarding the number of owner-occupied barely reaching 60%. The repetitive pattern makes these buildings perfect for large scale building envelope retrofitting, making use of modern technologies. Using a base model, the paper analyses different steel-intensive envelope solutions existing on the market adaptable to light-weight steel structural systems. The solutions enable flexible modular construction, fast fabrication short execution and easy disassembling. The analysis considers heat transfer including phase shift, amplitude attenuation and TAV (temperature amplitude ratio) and overall energy balance. Considering sustainability, Life-Cycle situations are evaluated.

Humidity Distribution in the Internal Environment: An Experimental Approach

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As opposed to other interior environment parameters such as temperature, ventilation and thermophysiological response, the distribution of humidity in internal micro-climates has not been widely examined. Furthermore, in a room without any sufficiently high latent heat sources, the spatio-temporal distribution of humidity inside the room is typically considered to be minimal. The authors have thus conducted a study in which inlet and source variations of humidity in a micro-climate are being analysed. This was carried out by designing and constructing a test chamber in which experimental test cases were analysed. The authors have then created and validated a numerical model to further study the spatio-temporal distribution of humidity in such a micro-climate. Nonetheless, this paper aims to detail the setting up of the experimental campaign, together with the analysis of the experimental results obtained. This paper will show how the temporal variations of humidity in an internal environment are highly dependent on the conditions at the inlet to the micro-climate being studied. Furthermore, the spatial distribution of humidity in the test chamber is being analysed under several source conditions inside the room. The study also compares the temporal exponential decay and increase in temperature and humidity respectively, following an initial high temperature, low humidity inlet to the micro-climate.

Designing new residential building in line with the Paris Agreement: a case study from Czechia

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In order to reach the climate mitigation targets provided by the Paris Agreement, all industrial sectors need to massively reduce their GHG emissions. European building stock is responsible for one third of the GHG footprint and construction is one of the key sectors in the climate change mitigation. Objectives: The objective of the paper is to describe the impact of the climate-related targets transposed to the national level into design of new residential buildings. Methods: National target for residential buildings is set and a standard design of a residential building is compared towards it. Then improvements to the building are made in order that it gets inline with the target. Results: Several tweaks in building's construction and energy system was needed, but the target is achievable.

Eco-friendly wall blocks using mineral foam and bio-composite insulation

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The work is devoted to the development and evaluation of energy-effective and sustainable wall structures. Traditionally, one-layer wall blocks are used, such as AAC (autoclaved aerated concrete) blocks and LWAC (lightweight aggregate concrete) blocks. AAC blocks are sensitive to external moisture and could meet durability problems, but LWAC usually requires additional thermo-insulation. The use of sandwich-type wall blocks makes it possible to provide necessary bearing capacity and thermal insulation. In this research, several types of innovative sandwich-type wall members are elaborated and evaluated. As a bearing material, high performance foamed concrete (HPFC) was developed. It is produced by cavitation mixed-foaming technology and reinforced with short non-metallic fibres. This material has higher mechanical strength, durability, and ductility, comparing to AAC. Lightweight aggregated were added in order to control shrinkage and enhance thermal conductivity. In order to provide thermal insulation, traditionally foamed polymer layers are applied - EPS (0.033 W/m*K) or special polyurethane (extra-low thermal conductivity 0.018 W/m*K allows to decrease the thickness of insulation). The possibility of replacing polymer-based thermal insulation with mineral-based material - ultra-light foam concrete insulation has been investigated. This approach could improve fire resistance and exploitation safety of the wall elements. The next development is a combination of load-bearing foam concrete layer with natural fibre bio-composite (such as hemp concrete and wood cheap board. In this solution, excellent thermal properties and additional effect of acoustical insulation can be achieved. Basic properties of sandwich blocks, such as density, mechanical strength and thermal conductivity, were evaluated and compared with traditionally used blocks. The use of layers of natural fibre bio-composite and mineral insulating foam makes it possible to obtain eco-friendly and sustainable sandwich-type wall system. The environmental impact of the investigated blocks was analysed using life cycle assessment. The results show that the replacement of traditional insulation with bio-based materials greatly reduces the environmental impact of the sandwich blocks.

On localization and reasons of insufficient air-tightness of used building envelope structures and their junctions

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Constantly rising prices of thermal energy and increasing heating costs force people to think about the measures that could help to save energy and reduce building heating costs without worsening the comfort of life. Proper insulation of building envelopes and air permeability control of premises are the main factors determining the efficient use of energy in built environment. In winter the air flow emerges because of the difference in pressure between the internal warm rooms and external cold air. Air moves from higher to lower pressure zone thereby cold outdoor air enters the premises through the cracks and leaks in various building structures cooling not only the building envelope but also reducing indoor temperatures. The more uncontrolled cold air penetrates the premises through various leaks, the higher the energy consumption is to heat the building. The energy losses of this type can be reduced by increasing the air-tightness of building envelope and its structural parts junctions. The aim of this research is to identify air permeability locations and the causes of their occurrence of the most common types of structures in Lithuania.

Added values in building renovation: An interdisciplinary research agenda

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This paper presents the research agenda of the Danish societal partnership project ReVALUE: Value creation by energy renovation and transformation of the built environment – modelling and validating of utility and architectural value. The paper will unfold how important the building sector is to the challenge of reaching a CO_2 neutral society, how the added values might be a catalyst to reach this goal, and how several tasks within the ReVALUE project is working on quantifying different types of added values. Denmark aims for a CO_2 neutral society by 2050. This ambitious goal cannot be obtained without a drastically reduced energy use for construction and operations of buildings. Buildings are responsible for 40-50% of the total energy consumption today and it has been found that the greatest energy saving potential lies in the renovation of the existing building mass. It is estimated that the existing energy consumption for Danish buildings should be reduced by 73% to meet the ambition of a CO_2 neutral society. Approximately 75% of the buildings that exist today will still be in operation in 2040. Hence, a considerable amount of the existing building mass must undergo a substantial

energy renovation to comply with the ambition of a CO_2 neutral society. Recent studies have calculated that cost-efficient energy renovation of the building envelope and technical installations of the existing building mass will lead to an energy reduction of 20-35%, which is far from sufficient if Denmark is to become a CO_2 neutral society by 2050. The current challenge is therefore to develop more cost-effective renovation solutions. As a response to this challenge, the societal partnership project called ReVALUE brings together companies, consultancies, and knowledge institutions in an effort to identify and quantify the "added value" of energy renovation measures. The hypothesis of the project is that these added values can justify more extensive energy saving measures than just sheer energy payback economics. The project focus on quantifying added values in terms of 1) architectural transformation, 2) health and comfort, and 3) construction management and productivity. The more specific challenges identified within these domains of added value is given in the following. Architectural transformation: There is no doubt that the largest potential for energy savings in the existing Danish building stock lies in the re-insulation of the building envelope. The transformation towards a more energy-efficient building mass will thus dramatically affect the built environment. Hence, the question of articulating the architectural consequences and derived potentials of this transformation are an urgent matter if the energy savings are not to be realized by a uniform technical cladding which devaluates the building. The challenge of transforming the building mass to become more energy-efficient not only calls for technical development and innovation but to a great extent also calls for the development of an architectural strategy, which is capable of articulating and realizing the architectural potential within the transformation process and thereby add value. Health and comfort: The main purpose of buildings is to provide healthy and comfortable environments for human activities. People spend 80-90 % of their life indoor and about 16 hours every day in their dwelling. The impacts that people are exposed to in the indoor climate are, therefore, of great importance for their health and comfort. Current research and practice have shown that people too often are unsatisfied with the buildings they use and that complaints concerning health and comfort are common. But research also connects good indoor climate to the better quality of life, reduction of health care cost, less absence due to sick-ness and superior work. Consequently, there is a significant and unexploited personal and societal value in realizing energy saving potentials with special attention to "the human factor". Construction management and productivity: Much waste can be avoided, project deadline and budgets can be meet, and more value for money delivered to the client, if the construction process is improved by early engagement of contractors, and lean planning and production control methods are implemented. The ReVALUE project showcase how implementing initiatives like LBMS and LPS can improve productivity on site, and deliver added value for stakeholders. The end goal of the ReVALUE project is to develop and demonstrate the validity of a generic renovation assessment method that not only includes the energy-economic aspect of renovation but also includes assessment and quantification of added values. This method will allow client and decision makers in renovation projects to identify a cost-efficient solution in terms of energy performance as well as create utility and architectural values by means of energy renovation, refurbishment and transformation in the built environment.

Feasibility study of sensible and latent heat recovery for medium-sized offices in a typical Mediterranean climate

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The new Energy Performance of Buildings Directive (EU) 2018/844 has brought about a new drive to renovate existing buildings, especially for heating and cooling systems, whereby heat recovery techniques have become the order of the day. However, the real energy and financial benefits of applying such techniques have not been studied in Malta, which has a temperate Mediterranean climate. Thus, this study has performed a technical and financial analysis of using different heat recovery options for the most common office type, that is a medium-sized flatted office, using EnergyPlus dynamic simulation tool and multiple linear regressions. Results showed that the coefficient of performance of the air-conditioners, the window to wall ratio and the cooling set-point temperatures, have the greatest impact, while heat recovery has an insignificant contribution to energy efficiency, thus making it rank low in the list of energy efficiency priority measures for medium-sized offices in Malta.

Integrated design approach studies towards Nearly Zero Energy Buildings in Malta: Climate-based simulations to improve the daylighting and thermal comfort performance of a building occupied by public authorities at the early stages of the design process.

Luca Caruso

The current Maltese legislation regarding energy performance of buildings states that by 31st December 2018, buildings occupied and owned by public authorities must achieve the Nearly Zero Energy status (nZEB). Currently the local energy code which would duly set up the minimum requirements for a new-built nZEB in terms of its overall efficiency of building-plant system is still at its infancy as a national plan: indeed it has only set out a maximum primary energy limit. Scope of this publication is to explore the advantages of using open-source building simulation tools (BST), for climate-based simulations, at the early stage of the design process to predict the variability of daylighting and thermal comfort metrics for various design options and their impact on space heating, space cooling and lighting needs. Daylighting and thermal comfort studies results will be presented following the EU Level(s) reporting tool template and compared to the minimum requirements of an international green rating scheme for new constructions. The predicted energy performance figures will be based on the design-rating of the building according to ISO 13790, based on the selected energy efficient systems and integrated by Renewable Energy Systems.

Technique for Optimsing Natural Daylight Using Double Curvature Deep Grid Shell and Upcycled Materials

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The paper discusses the advantages of using a deep grid shell glazed skylight for maximising the use of natural daylight.It is supported by a real life example measuring 15 mtrs x 9 mtrs that has been constructed and monitored over ten years. The geometry of the structure has been designed to allow maimum daylight whilst avoiding direct sunlight. The actual materials utilised for the realisation of the structure are a combination of recyclable materials and upcycled structural components. Innovative use of pretensioned tied arch provides a solution for maximising the strength of the available materials.The results of models showing form optimisation are included in the study. The paper includes a solution for using similar sized panels to realise two intersecting double curvature grid shells.

Sustainable Daylighting Technologies

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This paper presents a sustainable passive solar horizontal light pipe technology that not only introduces daylight in building cores without the negative effects of occupant's glare and building's solar heat gains, but also produces light stimulus to occupant's circadian system at 7.6m away from the window plane, similar to those areas adjacent to windows. The light pipe system is designed to introduce daylight passively in any floor of deep-plan multi-story buildings (9m-12m). It can be placed within the ceiling plenum with a collector that extends 0.25m from the building facade plane, so that it could be used with flush and articulated facades. The light pipe provides supplementary illumination at distances between 4.5m and 10m. It introduces consistently throughout the year illuminance levels between 300-2,500 lux at 9m from the window wall for more than 9 hours. Exposing building occupants to bright light (>1,000 lux) can help regulate the timing of their circadian rhythms, which has a direct effect on sleep patterns, alertness and performance. This passive solar light pipe is an energy efficient sustainable technology that utilizes direct solar energy, and provides high illuminance levels of full-spectrum light without the negative effects of glare and solar heat gains that are found in buildings with large expanses of glass.



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Sustainable Built Environment

A Case-study on Leachate Treatment in Dompe Sanitary Landfill, Sri Lanka

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Open dumping is the most common practice of solid waste disposal in Sri Lanka and the leachate generated is not managed and treated properly. This leads to many environmental, socio-economical and health related problems. Therefore, proper solid waste management and leachate treatment become vital in Sri Lanka. Dompe sanitary Landfill is the first ever engineered/sanitary landfill constructed in Sri Lanka addressing the above issues. This case study is based on characterization of raw leachate and evaluation of treatability of the existing combined treatment facility, Sequencing Batch Reactor (SBR) system followed by a constructed wetland in the landfill. Several parameters such as COD, BOD5 , TSS, TN and PO43- etc. were analyzed using 15 raw leachate samples, collected in 5 shifts covering dry and wet seasons. The treatability was evaluated by analyzing the effluent leachate samples after each treatment unit. Maximum COD, BOD5, PO43- and TN values were 6430mg/l, 3210mg/l, 52 mg/l and 383.75mg/l respectively in dry seasons. Maximum treatment efficiencies of COD, BOD5, PO43- and TN in the combined treatment facility were 98%, 99%, 93% and 91% respectively and met with CEA standards of discharging into inland surface waters.

Evaluation of Climate Change Related CSR Activities in the Hungarian Agrobusiness

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The corporate sector is one of the most important contributors to the global emissions of carbon dioxide and other greenhouse gases. According to a public opinion survey (in which 1000 randomly selected adult were interviewed by CATI method), 34.2% of Hungarian citizens believe that corporations are responsible for climate change. It is close to the European Union survey which shows that 41% of EU citizens consider companies to be responsible for climate change. The business sector is motivated to take an active role in the mitigation and adaptation of climate change. As a result, the last few decades saw a marked increase in corporate measures aiming at the reduction of greenhouse gas emissions, as well as other initiatives to tackle climate related problems numerous social issue. The research makes an effort to explore the role and opportunities of Hungarian agricultural sector in adapting to climate change, it also examines the extent of the mitigation and adaptation activities appearing in the CSR portfolio of the companies and what specific measures are taken to realized them. The empirical data in this study is based on information provided in annual statements, integrated or sustainability reports and corporate websites. Based on the information revealed, we make development proposals for businesses so the findings of the research can be used to support companies to adapt to climate change.

A Framework for the assessment of Sustainability in the Built Environment: The Case of Malta as an Island State

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The aim of the study is to develop a framework for the assessment of sustainability, based on specific indicator groups. The framework is intended to provide a perspective on the critical factors affecting sustainability in Malta as an Island State, with particular reference to the built environment and environmental sustainability. The objective is to assess the effectiveness of actions that may reduce greenhouse gas emissions [GHG] and improve the overall built environment. The framework served as the basis for the research methodology, referring to a qualitative and quantitative survey, based on groups of indicators which include: built environment, transport, resource depletion, waste management, air quality, water use & quality and energy & renewables. The survey was designed to provide a bottom-up view of GHG reduction actions to complement top-down policies and action plans developed by national authorities and large non-government organizations. Key stakeholder groups in the building industry were identified including architects and engineers, project managers, manufactures of building products, developers, contractors, building owners, users and other stakeholders. The research objective is to propose a framework for assessment of sustainability and on the basis of this, assess the relative importance of the indicator groups at the local level, with reference to Malta as an Island state. The outcomes of the survey are analysed in order to assess the critical parameters for a sustainable built environment. The results support also the formulation of multiple actions and a policy framework for green buildings and sustainable urban areas.

Circular Economy: A Solution for Construction Waste in Malta

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Significant waste is generated by the construction industry. 34.7% of all EU28 waste is generated by the construction sector leading to ca 28% of all CO_2 emissions. Construction and Demolition Waste (CDW) varies depending on the type of project, for example civil engineering works and infrastructure as against buildings. It includes materials such as masonry blocks, concrete, tiles and ceramics. CDW is usually non-hazardous although a small percentage can be hazardous and harmful to humans and the environment. Excavation waste amounts to a large and significant portion of the waste generated in construction activity. In less developed European countries, less than half of CDW is recycled. This has negative environmental impacts directly as a result of disposal and pressures on land and scarce resources but also pollution and greenhouse gas emissions. A way to decrease the negative impact of the construction sector is to foster its transition towards a circular business model in which resource and material efficiency, waste reduction, material value maximization and smart design are key priories. This paper highlights the current situation concerning CDW in Malta and then moves on to discuss measures that can be adopted to incorporate recycling of building waste within the Maltese circular economy. Tools such as the Build Circular Up tool, recently developed as part of the Build-Up Circular project, funded by EIT Climate KIC are presented. The tool is aimed at supporting the construction industry to transition towards circularity by creating a self-assessment digital innovation tool for the construction sector. The tool provides a snapshot of the current positioning and opportunities for further improvement, validation and certification of the relevant stakeholders.

Navigating resilient nodes of negotiation and emerging knowledge strands over project life-cycles

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Project objectives are established formally upon signing construction contracts, but variations almost invariably occur partially as a result of evolving social aspirations and uncertainties internal to projects. These shifting stakeholder requirements during project life-cycles affect pre-set objectives distorting the presumed equilibrium reached at contract stage, compounding to real and perceived performance problems and inefficiencies generally associated with a fragmented construction meta-industry. This conference paper hypothesises that if client expectations shift during construction, then the perceived efficiency of individual construction packages will be impaired but may still benefit the project in the long-term. Formal managerial models may not suitably portray the implications of changes to the original scope emerging over project life-cycles thereby accentuating deficiencies and hiding the industry's true resilience capabilities or vice-versa. The research seeks to clarify possible variations between reality and theory which affect configurations of the construction iron triangle metaphor at pre- and post- contract stages from the perspectives of clients, as demand drivers, and contractors as suppliers. A multi-dimensional 'resilience model' is proposed illustrating knowledge strands and nodes of negotiation through project life-cycles, enquiring whether given the perpetual turbulent environment in which construction operates, there is merit in embracing dynamic negotiation as symbolically equivalent to a carrier of growth, development, functioning and reproduction of knowledge.

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