Eco-efficiency

R. P. Borg

University of Malta, Malta

M. Veljkovic

Luleå University of Technology, Sweden

INTRODUCTION

"New materials, products and technologies are in the long term the necessary way to reduce environmental impacts. Construction products play a major role in improving the eco-efficiency of building. Radical innovations are needed for a real change towards sustainability." Memorandum of Understanding, COST C25, Sustainability of Constructions: Integrated Approach to Life-time Structural Engineering.

Sustainable development, is development that is pursued in a manner that whilst meeting the present needs, does not compromise the ability of future generations to meet their own needs.

The papers presented in this chapter focus on two main areas:

- Identification & Evaluation of existing & new functional materials, construction products & processes, to comply with a reduction in the use of materials, a reduction of waste, reduction of emissions and energy saving goals.
- Improvement of the environmental performance of constructions, improvement of comfort in buildings, energy performance and the integration of innovative systems in buildings.

Sustainability in Construction, necessitates a better comprehension of construction materials, their performance, and the impact of construction techniques, with the objective of the Conservation of Resources.

Increased conservation of resources is one of the most significant principles of sustainability of buildings and constructions, which can also be achieved through the adoption of rational structural solutions, and the selection of construction materials of improved performance characteristics and increased strength.

Increase in the specific strength of structural elements, leads to a decrease in material consumption. Serdjuks D. et al discussed the possibility of the development of hybrid composite cables of increased specific strength, using carbon fiber reinforced plastics (CFRP), glass fiber reinforced plastics (GFRP) and Vectran, instead of steel cables. Hybrid composite cables with increased specific strength were considered for a prestressed saddle-shaped cable roof having dimensions 50m x 50m, leading to savings on materials and energy in the production process. (Serdjuks D., 2007, Composite Cable of increased specific strength, for large span structures.)

Silva N. et al, analysed the benefits of the incorporation of Phase Change Material (PCM) in gypsum plasters. This system presents environmental advantages leading not only to enhanced comfort but also economic benefits, with respect to conventional gypsum plaster. The assessment demonstrates that the PCM system is characterised by similar impacts in all categories; however it reveals a reduced impact in terms of Global Warming Potential due to energy conservation. (Silva N. et al, 2007, Environmental characterisation of gypsum-PCM plasters.)

The assessment of the performance of materials in practice is important in view of durability. Norvaisiene R. et al carried out a number of experiments intended to improve the test methods for the investigation of facade paint durability, by allowing for the impact of air pollution. The results for samples after 96 days of exposure in the climatic chamber, were compared with results obtained for unexposed and naturally weathered samples. The correlation between natural weathering and the accelerated artificial ageing was found to be sufficient. (Norvaisiene R. et al, 2007, The development of a new methodology for the estimation of durability of facade paints.)

The main concerns in wood construction, are associated with a relative reduced efficiency of the material, the low strength spectrum, anisotropy and preservation. Haller P. assessed the potential for innovation of wood, through the efficient use of the raw material, by improving its properties, cross-sections and production techniques. These developments lead to various improvements which include the reduced prices of materials; the densification of wood that surmounts the limits of the strength classes; the use of textile reinforcement as a technology that solves the problem of anisotropy at a favourable price and provides weather protection; and the shaping of efficient cross-sections. (Haller P., 2007, From tree trunk to tube or the quadrature of the circle.)

Welzbacher C.R. et al assessed the biological and mechanical properties of Norwegian spruce, which was densified in a common industrial scale process and afterwards thermally modified in an Oil-Heat treatment process. It was reported that the durability increased considerably as a result of Oil-Heat treatment. While the dynamic mechanical properties of densified and Oil-Heat treated spruce were reduced when compared to controls, the static bending strength was equal to untreated spruce. Densified and thermally modified samples demonstrated improved dimensional stability when compared to untreated densified material. (Welzbacher C.R., 2007, Biological and mechanical properties of densified and thermally modified Norway spruce.)

The concept of conservation of resources was discussed by Borg R.P., in the assessment of practical solutions with regards to the management of excavation, construction and demolition waste. The waste hierarchy provides an order of priorities for deciding on waste management practices, including the Reduction in Waste, and therefore minimizing on the use of resources and reducing the quantities of waste; Reuse of materials; Recycling and reprocessing of the waste material, for use in the manufacture of the same or different materials; Recovery of energy; and Disposal of waste, whereby waste is disposed without energy recovery only if there is no other appropriate solution.

Various proposals for waste reduction, reuse and recycling were assessed within the framework of the Waste Management Strategy. Potential measures need to be analysed in terms of environmental impact and economic feasibility. Solutions for waste management include the recycling of excavation, construction and demolition waste for use in Civil Engineering applications. The potential disposal of inert waste was also assessed with reference to disposal in quarries, and reclamation of land from the sea. (Borg R.P., 2007, A Sustainable Waste Management Strategy: Construction & Demolition Waste.)

The use of recycled materials was further analysed through experimental work conducted by Jevtic D. et al, on the properties and performance of cement composites based on recycled brick aggregate. In particular the density, compressive strength, flexural strength and shrinkage were assessed. The test results obtained for the mechanical properties of fiber reinforced recycled brick composites indicate that the addition of polypropylene fibers generally leads to improvements of these properties. The results indicate that there can be a wider scope for the application of concrete produced using crushed recycled brick aggregate. (Jevtic D et al, 2007, Properties and performance of cement composites based on recycled brick aggregate.)

The properties of concrete were also investigated by Malesev M., et al, in an experimental investigation on the use of recycled concrete as aggregate for structural concrete. A comparative analysis of the properties of fresh and hardened concrete with natural coarse aggregate, combination of natural and recycled coarse aggregate and with recycled coarse aggregate, was carried out. Concrete mixtures with recycled aggregate were noted to be very similar to concrete mixes with natural aggregate, and the performance of the Recycled Aggregate Concrete was satisfactory. (Malesev, M. et al, 2007, Recycled concrete as aggregate for producing structural concrete.)

In the selection of construction materials, the entire life cycle of the building must be considered, covering not only construction, use and maintenance, but also waste disposal. Factors that need to be assessed in planning an environmentally sustainable and cost effective building include minimal energy, minimal maintenance, minimal waste and suitability for local climate. Ermolli S.R. et al discussed the contribution of aluminium systems towards the sustainability of structures. New building systems and innovative design concepts incorporating aluminium alloys are adopted to provide more sustainable solutions. (Ermolli S. R. et al, 2007, Sustainable Aluminium Systems.)

Kozłowski A. et al, present inventory data collection for a light gauge steel frame structural system that can be used for residential and commercial buildings. The Life Cycle Inventory analysis of the system was performed for boundaries covering manufacturing processes. (Kozlowski A., 2007, Preliminary Life Cycle Inventory analysis of light gauge steel frame system.)

Numerous methods are utilised for the estimation of the energy consumption in buildings. A brief state of art of various methods is given by L. Berevoescu,et al. The methods used to assess the consumption of energy, are grouped into direct methods and reverse methods. (Berevoescu,L. et al, 2007, Energetic audit methods, part of sustainable development process.)

An analysis of the housing stock situation in Romania is presented by Dan D. et al. This is followed by an assessment of the requirements for the resistance to heat flow of elements of the building envelope, and a discussion on the latest trends in construction. The building enevlope solutions adopted before 1984 were inadequate, while new improved solutions that were developed for exterior walls, were not used in practice due to initial higher investment costs. The Order issued by the Romanian Government in 2000, concerns the thermal rehabilitation of existing buildings and stimulates energy saving in buildings. A commercial center in Timisoara, Romania is used as an example of good practice, and illustrates this positive trend. (D. Dan, at al, 2007, Energy efficiency of old and new buildings in Romania.)

Dan D. et al discussed the efficacy of the thermal rehabilitation of a student hostel, and analysed the economical benefits of the solution adopted. The solution adopted includes improvements in the global thermal resistance of the building envelope, with the aim of reducing the loss of energy. The amortization period of the investment is reported to be about 6 years. The energy classification of the building stock, can be considered as an effective management tool. (D. Dan, at al, 2007, Thermal rehabilitation of a student hostel belonging to the Politehnica University of Timişoara.)

The thermal performance of houses built using different construction techniques in the Izmir region in Turkey, were compared by Altin M., et al. Houses built using traditional and conventional techniques are compared to light-weight houses. (Altin M. et al, 2007, Comparison of the improvement of comfort in Turkish houses which are built by using traditional, conventional and semi-industrialized construction methods.)

Werner G., reviewed a study conducted by the Swedish building and energy sectors, with the aim of identifying the most cost-effective and resource-efficient measures for the reduction of the environmental impact of buildings. The goal was to attain a system for energy supply, with the least possible environmental impact. (Werener, G, 2007, Low energy building design with sustainable energy end use.)

An integrated approach is necessary for an adequate assessment of construction materials, construction techniques and structural systems. The papers presented in this chapter address a variety of subjects, but have a unifying principle: Conservation of Resources. Innovation in construction and the potential development of emerging technologies and new materials, are essential towards achieving the goals of energy efficiency and resource management, within the context of sustainability in construction.

Improved performance requirements of buildings, necessitate an adequate analysis of energy efficiency of buildings. This enables the formulation of strategies based on adequate priorities for rehabilitation and construction, in the context of improved comfort and sustainability. The challenge is also to assess successful low energy building design solutions in different climate zones, and to gain sufficient knowledge towards effective solutions in different circumstances.

The contributions presented in this chapter, are yet another step, towards the objectives of COST C25, and for an integrated approach in the assessment of sustainability in construction.