Eco-efficiency

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Construction activity is associated with considerable environmental impacts in general. Construction processes are considered to be linked with consumption and exhaustion of natural resources, destruction of natural habitats, waste generation and pollution. Construction is therefore an important area where environmental sustainability needs to be promoted, in order to allow for a reduced impact on the environment. Sustainability in construction draws from the concept of Sustainable Development, which is based on the environmental, economic and social domains.

The environmental impact of new and existing structures is reduced through a life cycle approach. The life cycle includes the production of materials, transport, building processes, operation and maintenance, and the end of life. A life Cycle Assessment can help identify the potential for improved environmental performance. The total energy use needs to be addressed in a life cycle perspective, in order to identify the critical phases in the life cycle.

It is therefore relevant to address the following;

- Assessment of existing and innovative materials, products and processes, with the aim of achieving the goals of a reduction in material consumption, decrease in the waste generated, decrease in emissions and reduced energy consumption.
- Improved environmental performance and improved comfort in buildings, improved energy performance, and the integration of innovative systems in construction.

The concrete industry is considered to be a large consumer of natural resources. In particular the quarrying, processing and transport of aggregate, and the raw material necessary for the manufacture of cement, lead to a considerable consumption of energy, and affect adversely the ecology. The potential recycling of waste materials, including recycled concrete, results in a reduction in waste disposal, and a reduced consumption of natural resources. Borg R.P. et al addressed the Life Cycle Assessment of concrete. Various aspects need to be taken in consideration when assessing the potential production of recycled aggregate concrete (RAC), including the assessment of the rheological, mechanical and durability properties of various types of RAC; investigation of the potential of the utilization of RAC in the production of structural concrete; and comparative analysis of the environmental impact of natural aggregate concrete (NAC) and RAC. (Borg R.P. et al, Life Cycle Assessment of Concrete.)

Marinkovic S. et. al. addressed the life-cycle environmental impact assessment of natural aggregate concrete, produced in Serbia. Most of the data used for raw material production, concrete production and demolition and transport was provided from suppliers and manufacturers in Serbia. The environmental impact categories studied in the work were: Energy Use, Global Warming Potential (GWP), Eutrophication Potential (EP), Acidification Potential (AP) and Photochemical Oxidant Creation Potential (POCP). The analyses performed identified the production of cement as the main contributor to all the impact categories assessed. The authors also concluded that the contribution of transport can be significant, especially with regards to POCP and to a minor extent, to EP, which directly depends on the transport distances. (Marinkovic S. et al, Life Cycle Environmental Impact Assessment of Concrete).

In order to address the overall environmental impact, all the life cycle stages of a structure need to be taken into account, including the construction materials, construction activities, demolition and dismantling, and recycling of waste materials and disposal. The end of life phase includes also demolition, and recycling of waste materials. A comprehensive investigation and a detailed assessment of damages are necessary, in the appraisal of existing structures. In this regard, Borg R.P. assessed the investigation carried out on a deteriorated concrete bridge structure in Malta. The proposals for reinstatement were based on the investigation and the damage assessment, and also on other criteria which were specific to the particular project. The proposed solution included the demolition of the existing deteriorated bridge superstructure, and renewal of the superstructure as a continuous 3-span cast in place box girder, together with the rehabilitation of the substructure. Waste materials were considered for recycling, included in particular steel reinforcement, and concrete, which was considered for the production of recycled aggregate concrete. (Borg R.P., Assessment of a Bridge Structure, Demolition and Recycling of Materials.)

The use of metal such as light gauge steel materials and aluminium alloys, in innovative metal systems is becoming more popular since both architectural and structural requirements can be addressed. Efthymiou E. et al carried out a comparative study of the eco-efficiency of different structural metal systems which are used in residential applications. The authors referred to the sustainable use of light gauge steel frames and aluminum structural frame systems in dwellings. The basic elements of the systems, range of applications and case studies are presented, with particular reference to the environmental and economic performance. The environmental performance was addressed through the application of a Life Cycle Analysis for the chosen systems, covering the production, transportation and execution of the structure. Conclusions with respect to residential houses were presented. (Efthymiou E. et al, Eco-efficiency of light metal structures in residential buildings.)

Engineered wood products can be produced on the basis of formed wood profiles, optionally reinforced with fibres and textiles, for structural purposes. The objective of the research presented by Heiduschke A. et al was to discuss the load-carrying behaviour of light-weight timber columns with circular hollow cross section. Full-scale axial compression tests were conducted to evaluate the performance of the profiles. Due to the high buckling strength, the tubes were capable of sustaining high axial loads. The tests demonstrated that the load-carrying capacity and ductility of the timber profiles could be significantly enhanced by additional fibre reinforcement. Finite element models were developed on the basis of the experimental results, to simulate and analyse the load-carrying behaviour of the tubes and their failure mechanisms. The numerical models were calibrated and verified through the experimental data to assess their reliability. The Life Cycle Assessment of the product indicated that due to the efficient use of the material, formed wood and wood composite profiles have a lower environmental impact in the production phase than comparable glulam elements. (Heiduschke A. et al, Mechanical Behaviour and Life Cycle Assessment of Fibre-Reinforced Timber Profiles).

Aerogel is a low-density solid-state material in which the liquid component of the gel has been replaced with gas. The result is an extremely low density solid with several remarkable properties, in particular its effectiveness as an insulator. The materials is semitransparent. The particular properties of the material including its low density, and low thermal conductivity lead to potential applications of the material in construction. Stoian V discussed the properties of aerogel, and addressed the potential use of the material in construction. (Stoian V., et al, Aerogel a New Performant Material to Increase the Energy Efficiency in Buildings.)

Stoian et al discussed the potential improvement of the global performance of constructions. The authors addressed the initial and additional investmenets during the lifetime of the structure. In this regard, Global Cost was addressed with respect to new construction, and also the rehabilitation of existing structures. (Stoian V., Life Cycle Cost Analysis and Eco-efficiency in Buildings.)

Optimum comfort in the built environment is an important aspect that must be considered during the design phase. Optimum solutions depend on the choice of the right materials and suitable installations. Techniques for the improvement of the comfort in buildings, and techniques for the improvement of the environmental performance of buildings and infrastructure are important issues of sustainable construction. The roof is an important element which contributes towards the environmental performance of the building. Yilmaz Karaman O., et al compared roof construction systems used in Turkey with respect to the selection of materials, sound insulation, thermal insulation, and economic aspects. (Yilmaz Karaman O., et al, Examination of different roof constructions that are widely in use in Turkey from the viewpoint of improvement of comfort in houses)

In order to establish guidelines for optimization of water management, G.Assefa addressed effective water saving measures. Such measures were considered through a holistic approach that focused on individual buildings, while considering a broader view of the urban areas. The first step included the definition of a system boundary. Building types such as residential buildings, offices and other buildings (e.g. schools) were addressed. In the case of residential buildings unique features relating to building typology were accounted for. The downstream component of the wastewater systems was included. The basis of analysis adopted was the optimization of the per capita use of water. The approach in identifying the areas of possible optimization was a need-based approach the core part of which consisted in the definition of water use. For each area, relevant stakeholders were identified. Optimization at the level of the water supply system, water distribution network as well as water saving fittings, were discussed. Social aspects were also addressed. (G.Assefa, Identifying Areas for Optimisation of Water Management at the Building and Urban Level)

The life cycle phases of a structure cover various aspects in the life time of a structure, including the production of construction materials, construction activity, service life of the structure, and its end of life. An integrated approach is necessary in the assessment of the impact of construction materials and products, and structures on the environment. Sustainable construction, leads to a more econmical use of finite raw materials, and reduction of waste generated. Ongoing development of new materials and processes, and innovation in construction technology are essential to address sustainability in construction.