Editorial

The construction industry is one of the largest consumers of energy and raw materials and the highest contributor to the emissions of greenhouse gasses (GHG). In order to become more sustainable, it needs to limit its environmental impact and, in particular, it has to reduce the use of both raw materials and energy. At the same time, the construction industry needs to be cost efficient. With this in mind, the EU has set a challenge to the construction industry in its 7th framework programme to reduce the embodied energy consumption with at least 50% and a cost reduction of more than 15% compared to existing solutions while at least maintaining the performance. Secondary challenges were a reduction of 50% GHG and a reduction of primary materials of 20%.

Developing novel technologies to integrate waste as secondary materials in the production cycle of light weight (LW) concrete products is an all-inclusive solution that improves both sustainability and cost-efficiency of the construction industry since:

- the embodied energy of the concrete decreases due to the lower energy consumption in the production of the concrete constituents (most notably the binder),
- the CO_2 footprint reduces due to the reduction of processing of raw materials,
- the cost effectiveness increases due to the lower costs of the integrated component materials, being secondary.

To this aim, the EU-project SUS-CON [1] was started in 2011 to develop new concepts and technology routes to integrate secondary materials in the production of concrete, for both ready mixed and precast application, resulting in an innovative, eco-compatible and cost-effective construction material.

Making concrete more eco-compatible, energy- and cost-effective while at least maintaining its performance, is an enormous challenge. It is even more daunting from the prospective that concrete consists of a number of constituents, each having a different

[1] SUS-CON: 'SUStainable, innovative and energy-efficient CONcrete based on the integration of all waste materials', 7th Framework Programme, Grant 285463, http://www.sus-con.eu

impact on the material performance, on the environmental impact, on the energy efficiency and on the costs. The final results are governed not only by the individual contributions of each constituents but also by the combined effect of those constituents when mixed together. Considering that the two major constituents of concrete are aggregates and binder, it is worth noting that it is in general the binder that is mostly responsible of the energy consumption and CO_2 emissions as well as being the largest cost factor, whereas the aggregates have the highest impact on the thermal resistance and are the key constituent determining the thermal properties. With this in mind, the SUS-CON project aimed at the following:

1. to reduce the embodied energy and the CO_2 footprint of concrete by replacing the current binders by novel binders made from secondary materials only; the biggest challenge lies in the formulation of a binder of 100% secondary material that is durable and applicable for concrete at full scale application,
2. to produce novel aggregates composed of secondary materials only that are light weight and thermal insulating,
3. to combine the new aggregates and binders in such a way that performance of the eco-concrete is at least similar to already existing LW materials based on traditional binders and LW aggregates,
4. to add additional performance demands in the design methodology.

The reliability of the proposed solution was ensured by demonstration in mock-ups and its eco- and cost-efficiency by an LCA/LCC (Life Cycle Assessment /Cost) analysis.

In this special issue of HERON, five papers have been collected that together will give an overview of the research-based results of SUS-CON (Figure 1). The first paper deals with secondary material-based aggregates and their viability. Different secondary material types, different treatments for aggregations and their suitability as aggregates will be discussed. Also their suitability in traditional concrete, i.e. concrete with traditional cements was investigated. The analysis concludes with an overview of the potentiality of the examined eco-friendly aggregates for the manufacturing of sustainable concretes.

On the binder side, which is the topic of the second paper, research has been focussed on secondary materials that can completely replace the current cements, instead of to blending them. To this aim, the focus of the research has been on alkali-activated "cementless" binders that have recently emerged as a novel eco-friendly construction material with a promising potential to replace ordinary Portland cement. The suitability of these secondary materials as binder has been assessed through a detailed chemical and physical characterisation and the binder composition has been defined in terms of proper alkali activation dosages, water content in the mix and curing conditions. The mix design must satisfy mechanical and technological requirements for ensuring the suitability of the binder in replacing Portland cement in concrete applications. This paper offers a methodological approach for the development of secondary material-based binders, from identification to mix design and production procedure definition.

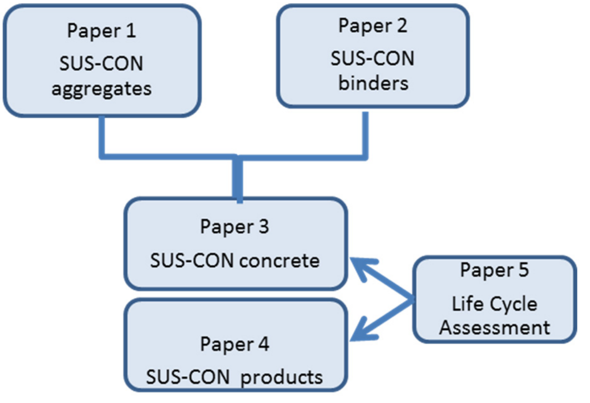

Figure 1: Relation between the papers in this special issue

Combining the eco-friendly aggregates with the alkali-activated binders to a concrete that has at least the same performance as ordinary concrete, as well as including other performance demands such as thermal insulation, is reported in the third paper in this special issue. As a radically different approach from traditional concrete design, a model has been developed for which density, elasticity properties and thermal resistivity can be predicted on the basis of the properties of its constituents. A fresh concrete testing programme has been executed to verify the properties and further investigate the interactions between the new binder and aggregates and their sensitivity to execution and curing. On the basis of the results of the fresh mortar research, nine concrete mixtures have been chosen for four different products that are aimed for in the SUS-CON project: (blocks, facade, screed and screed underlays). For these mixtures, the hardened concrete properties have been tested, including mechanical and durability tests as well as thermal properties (thermal insulation, capacity and expansion). The results are presented and discussed with respect to their suitability for the products.

Paper 4 deals with modelling of the performance of the SUS-CON concrete products, as the ultimate performance not only depends on the concrete compositions but also on the dimensions of the products and the environment they are placed in. Numerical studies have been used as a product design tool, to determine the performance of concrete products without actually making them. The present numerical studies were focussed on the prediction of the mechanical, thermal and acoustic performance of concrete products, which were divided in three dimension levels: "component-thickness" scale, "wall-thickness" scale and "house/building" scale. A multi-scale approach, from concrete components to building structures, has been developed. This also creates the possibility to optimize between the building products and their required performance on one hand and the available eco-materials with their properties on the other hand.

The fifth paper, about a life cycle assessment for SUS-CON concrete products, presents an analysis of the embodied energy and carbon footprint of SUS-CON concrete, taking into account all processes from waste sorting, pre-processing, transport and final use. Emphasis will be on embodied energy and CO_2 emission reduction because of the goals set in the project. It will also present an overview of the environmental advantages and disadvantages of SUS-CON concrete and its components, in building applications.

It is hoped that this special issue contributes to the further application of these and other eco-friendly materials in the construction industry, since then it also contributes to a more sustainable and green world.

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Reference

Arena, W., Attannasio, A., Marseglia, A., Pascale, S., Ristoratore, E., Rocco, B., Saracino, S. and Urbano, G. (2015), Market availability and mapping of waste streams across the EU27, SUS-CON publication, available from www.sus-con.eu