

Environmental and economic viability of the novel products

EnDurCrete precast elements for various applications (marine, tunnel, offshore structure, bridge) are designed and produced in order to demonstrate the properties of the concept in real life conditions. Strategic Life Cycle Analysis (SLCA) has been carried out for five EnDurCrete innovative products/technologies, precast concrete elements and complete innovative EnDurCrete system. These SLCA allowed the identification of a number of specific environmental and social challenges that can be further addressed in the subsequent detailed LCA.

The end-of-life phase was analyzed for the whole expected EnDurCrete system. Main negative findings related to end-of-life phase are the following ones:

- According to current status, the transport of waste to treatment would use fossil fuels. Situation after 140 years can however be different.
- Also the sources of energy used in current recycling are usually not fully sustainable. However, it is difficult to predict electricity mix in 140 years.
- There is the possibility of release of substances that risk accumulating in nature coming from innovative product components, especially when the construction wastes are landfilled.
- Dust from crushing or leaching of substances when re-used as road base can cause certain health risks related to end-of-life treatment and reuse. Proper safety standards (contemporary at time of product end-of-life) have to be applied.

Product	Description	SLCA phase		
		Raw Material	Production	Packaging and distribution/Use
Novel Portland composite cement	Novel <u>Portland Composite Cements</u> (PCC) including sustainable, high-quality supplementary cementitious materials that are valorised industrial by-products. The novel cements are produced by HeidelbergCement.	<ul style="list-style-type: none"> • Part of the raw materials are provided by the sub-contractors and the cement producer cannot directly influence the way the raw materials are extracted. • The raw materials are transported by the means of transport using fossil fuels. • Avoiding physical degradation of nature caused by raw material extraction is not possible unless all virgin raw materials used along the process of making cement are replaced by secondary ones. 	X	Cement is usually transported by state-of-the-art trucks driven by diesel.

<p>Precast concrete elements</p>	<p>Precast concrete panel/column/segment based on the novel materials produced in frame of EnDurCrete project. SLCA focuses mainly on the production of the typical precast concrete panel as commercially produced by Nuova Tesi.</p>	<ul style="list-style-type: none"> • The raw materials are extracted and transported by the machines using fossil fuels. • Extraction of raw materials (especially aggregates) is typical physical degradation of nature. • Aggregate extraction also typically causes accompanying negative phenomena for society, such as increased transport, noise, dust, destruction of roads etc. 	<ul style="list-style-type: none"> • Production of precast panels uses fossil energy. • Oil used for demolding can cause nature pollution (but only in case of accident or improper treatment). 	<ul style="list-style-type: none"> • Precast concrete elements are usually transported by trucks burning diesel.
<p>Smart corrosion inhibitors</p>	<p>Smart corrosion inhibitors for concrete formulation - laminar clays modified with alkoxy silane groups and anionic corrosion inhibitors. These additives will respond intelligently since the inhibitor compound will be only released from the clay when the corrosion probability increases, as a result of a pH decrease, determined by water and carbon dioxide, or chlorides concentration increase.</p>	<ul style="list-style-type: none"> • Clays used as basic materials have to be extracted as virgin materials, which lead to physical degradation of nature. • Extraction and transport of raw materials is done by machinery using fossil fuels (diesel). 	<p>Very positive results achieved for “Production” phase actually do not refer to industrial production but rather to laboratory scale production at IBOX. Therefore, the results for industrial scale production can be different.</p>	<p>X</p>
<p>Protective coatings</p>	<p>Innovative multi-functional concrete element coating material (paint) with self-healing properties and improved resistance to aggressive agent, with focus on deep sea exposure. This material is being developed by AMSolutions.</p>	<p>Many of the final product precursors are chemicals produced by third parties, therefore the access to necessary information is limited. Consequently, the predictive value of the analysis is rather limited.</p> <ul style="list-style-type: none"> • The raw materials and products are certainly transported using fossil fuels. • The raw materials can contain substances that are scarce in nature, such as Ag, Sn or In. 	<p>The result in phase “<u>Production</u>” is generally positive.</p> <ul style="list-style-type: none"> • Production uses materials that may contain substances scarce in nature. • Waste containing some of the scarce substances (around 100 ppm) and also substances that risk accumulating in nature is produced in limited amounts. 	<p>The results in phases “<u>Packaging and distribution</u>” and “<u>Use</u>” are generally positive.</p>

			<ul style="list-style-type: none"> • Electric energy is not completely purchased from sustainable resources. • The production uses chemicals that cannot be considered safe materials. 	
Self-monitoring reinforcing system	Multifunctional self-monitoring concrete reinforcing system developed by RINA-C. The main focus of this SLCA is the fiberglass grid as it is by far the main material of the reinforcing system.	<ul style="list-style-type: none"> • AR-glass scrims are made of alkali-resistant sodium zirconium silicate glass with a zirconium oxide concentration $\geq 16\%$. ZrO_2 can be considered scarce substance. • Raw materials are transported by the means of transport using fossil fuels. • The chemical additives can be sourced in the way causing some risk of accumulating harmful substances in nature. 	<ul style="list-style-type: none"> • The production process includes special materials (additives) that may contain materials scarce in nature. • Some of the materials used during the production risk accumulating in nature. • Production probably uses electric energy from grid, which is not fully sustainable. 	The negative result in SC2/Packaging and distribution life cycle phase is caused by the fact that the product is usually packed in plastic materials that can potentially cause risk when accumulated in nature. In addition, the distribution uses traditional means of transport using fossil fuels.
EnDurCrete complete product	The whole EnDurCrete system – concrete precast elements including novel Portland composite cement, self-sensing additions, smart corrosion inhibitors, protective coatings and self-monitoring reinforcing system.	The main sustainability challenges are related to “Raw materials” product life cycle phase. This is partially caused by the fact that the raw materials are almost always purchased from third parties and the possibility to apply sustainability principles directly by the project partners or future product producer(s) is limited.	X	All raw materials and products are at the moment transported by means of transport using fossil fuels. Although the possibility to replace them is currently very limited, it should be encouraged to seek for at least means of transport causing lower emissions of green-house gases and other adverse environmental impacts.