2020 April, 20

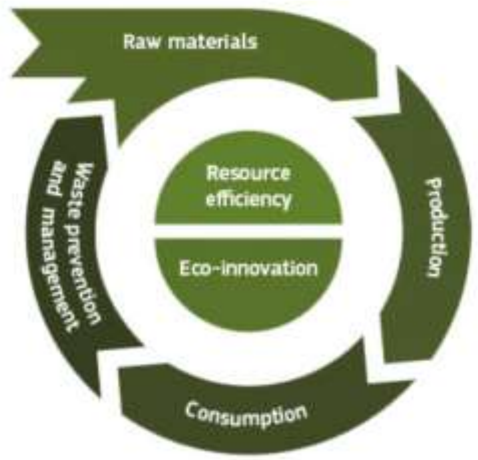
Circularity for sustainability in built environment: Renovate or recycle

Philbert Nshimiyimana; pnshimiyimana@doct.uliege.be
Ph.D. candidate; science and technology of engineering; ULiège & Institut 2iE

Secondary materials generated from construction and demolition wastes are potentially (re)usable for achieving circularity and sustainability in construction sector. The recycling is essential in order to limit the consumption of natural resources, energy and emission of wastes and polluting gases in the environment. This is a huge milestone towards responsible and sustainable development with regards to the well-being of future generations.

From circular process towards full sustainability

The circular building process uses resources efficiently, applying eco-innovation strategies; contrary to the linear process which takes, makes, uses, and then disposes, assuming no limit on the availability of (natural) resources. The circular process is rather more dependent on renewable resources. It ideally keeps the materials in closed loop[1], throughout the extraction of raw materials, production, consumption, prevention and management of wastes.

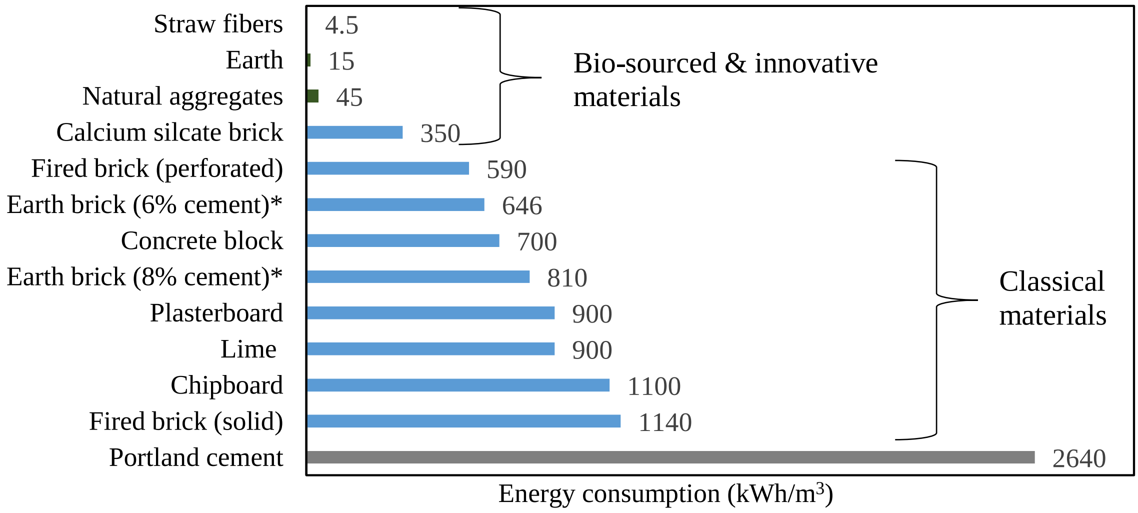


The Circular Economy tools and instruments of the European Commission; *https://ec.europa.eu/environment/green-growth/images/graphic-itemwhite.jpg*


The 17 Sustainable Development Goals of the UN agenda 2030; *https://sustainabledevelopment.un.org/?menu=1300*

The sustainable development is defined as "*a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*"[2] It is a broad term which covers the social, economic and environment issues. Among the 17 sustainable development goals (SDGs) established in the UN agenda 2030, the 11th consists of *sustainable cities and communities*.

In fact, the construction sector is one of the main human activities which impacts most the environment and threatens the well-being of future generations. This is illustrated by the scarcity of natural resources (e.g. sand[3]), usage of materials which have high embodied energy and carbon; i.e. consuming high amount of energy and emitting large amount of harmful green-house gases (GHG) during production (e.g. Portland cement[4]), dumping of wastes such as plastics in water[5], etc.



Embodied energy consumed for production of common building materials[6], * earth brick containing 6-8% cement[4]

Globally, the construction sector consumes about 40% of materials[1] and 30% of energy[1], excluding the production of materials, and produces about 50% of wastes and 20% of GHG (CO_2, …). For instance, about 16 % of 400 billion tonnes of single use plastics produced annually are used in built environment. The cost of waste is high for both environment and economy. Specifically, the impact on tourism, fishing and shipping is annually estimated at USD 1.3 billions in the Asia-Pacific oceans alone[1].

The wastes from construction and demolition consist of concrete, bricks, gypsum, tiles, ceramics, wood, glass, metals, plastics, solvents, asbestos and excavated soil many of which can be recycled. The recycling into secondary materials not only allows to recover their embodied energy but also save the natural resources. Moreover, the use of non-conventional, bio-based and/or low embodied energy materials such as earth, plant woods and fibers can allow to achieve the sustainability of source materials.

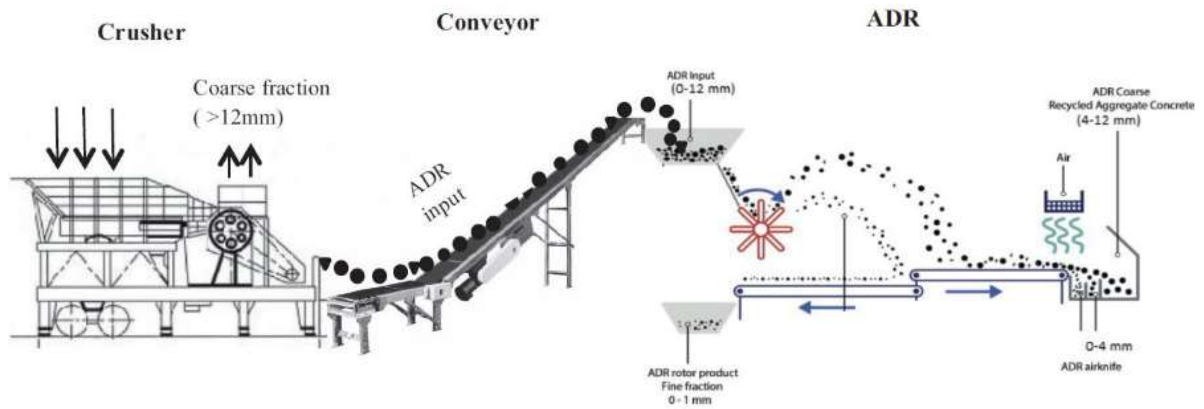
Hazards	Deconstruction	Dismantling	Demolition
-Asbestos -Lead, etc	-Doors -Windows -Woods -Metals	-Bricks -Beams -Structures	-Minerals -Woods -Scraps
For treatment/ disposal	For market/ recycling	For reuse	For recycling/ Disposal

Renovation or, in the worst scenario, de-construction _not demolition_ of existing buildings generates high grade wastes[7]

Prevent, reuse or recycle to achieve circularity in built environment: Case of construction and demolition wastes

The ideal scenario is to keep buildings last as long as possible. At the end of the life, the buildings are de-constructed, by systematically dismantling, so that the materials constituting each part are easily separable without need for further trial; instead of blind demolishing which would results in mixture of different types of materials. In the case of de-construction, the reuse of materials would requires little treatment, contrary to the case of demolition where there is need for intensive separation and treatment before any further reuse can be envisaged. The latter would be high energy intensive and thus more costly.

At early stages, design and implementation, actions need to be taken to use new high-grade building materials and elements, such as high performance concrete which records high durability, also incorporating a large recycled content to preserve resources. The design phase should envisage the disassembly, and the construction phase of new building should produce less wastes. The lifetime of existing buildings should be extended as long as possible during the use, throughout *renovation and restoration*. The selective demolition-deconstruction should be privileged at the end-of-life of structures to produce high grade reusable wastes and reduce the need for waste disposal.



Recycling of construction and demolition wastes into secondary aggregates: The principle of advanced dry recovery[7]

The construction and demolition wastes should be treated accordingly and re-integrated in construction, thus closing the loop. For instance, concrete wastes can be recycled into fine or coarser aggregates for production of new concretes. The process consists of crushing the coarser fraction (>12 mm) and separating into different fractions, from sand to gravel (0-1, 0-4, 4-12 mm) using technics such as the *advance dry recovery (ADR)*. The current recovery rate of non-hazardous mineral construction and demolition wastes ranges between 50 and 100%[7]. However, the sulfates and chlorides in fine fraction and the cement pastes adhered on the surface of coarser fraction challenge the usage of recycled aggregates in new concrete. Moreover, the applications of recycled aggregates can be envisaged for the stabilization and improvement of earthen materials, either for building construction or pavement[8].

Link the circular model in built environment to the SDGs

The circular model can be linked not only to the *sustainable cities and communities* but also other goals of the SDGs[1]. For instance, it is linked to the *good health and wellbeing*, *clean water and sanitation*, *affordable and clean energy*, *decent work and economic growth*, *industry innovation and infrastructure*, *responsible consumption and production*, and *climate action*. These actions consist of recycling and decontaminating of substances without risk to the environment: land, water or air, and human health. They also create new remunerated and local jobs for collecting wastes and minimize the consumption of virgin materials and energy in the production of innovative infrastructures

Further readings

1. Thelen, D. *et al. Scaling the Circular Built Environment_pathways for business and government; World Business Council for Sustainable Development & Circle Economy*. (2018).
2. Khatib, J. M. 1 - Introduction. in *Sustainability of Construction Materials (Second Edition)* (ed. Khatib, J. M.) 1–11 (Woodhead Publishing, 2016). doi:https://doi.org/10.1016/B978-0-08-100370-1.00001-9
3. Wrede, I. Not enough sand for construction industry despite abundance? *DW* (2019). Available at: https://p.dw.com/p/3L2Lu .
4. Venkatarama Reddy, B. V. & Jagadish, K. S. Embodied energy of common and alternative building materials and technologies. *Energy Build* **35**, 129–137 (2003).
5. Syngros, G., Balaras, C. A. & Koubogiannis, D. G. Embodied CO2 Emissions in Building Construction Materials of Hellenic Dwellings. *Procedia Environ Sci* **38**, 500–508 (2017).
6. Egenti, C. & Khatib, J. M. 13 - Sustainability of compressed earth as a construction material. in *Sustainability of Construction Materials (Second Edition)* (ed. Khatib, J. M.) 309–341 (Woodhead Publishing, 2016). doi:https://doi.org/10.1016/B978-0-08-100370-1.00013-5
7. Wahlström, M. *et al. Construction and Demolition Waste: Cchallenges and opportunities in a circular economy; European Enviroment Agency_European Topic Centre Waste and Materials in a Green Economy*. (2020).
8. Mango-Itulamya, L. A., Collin, F. & Fagel, N. Improvement of lifetime of compressed earth blocks by adding limestone, sandstone and porphyry aggregates. *J Build Eng* **29**, (2020).