Akka

A MODEL FOR CIRCULAR CONSTRUCTION IN MALTA

A COLLABORATIVE RESEARCH PROJECT BY A.COLLECTIVE,
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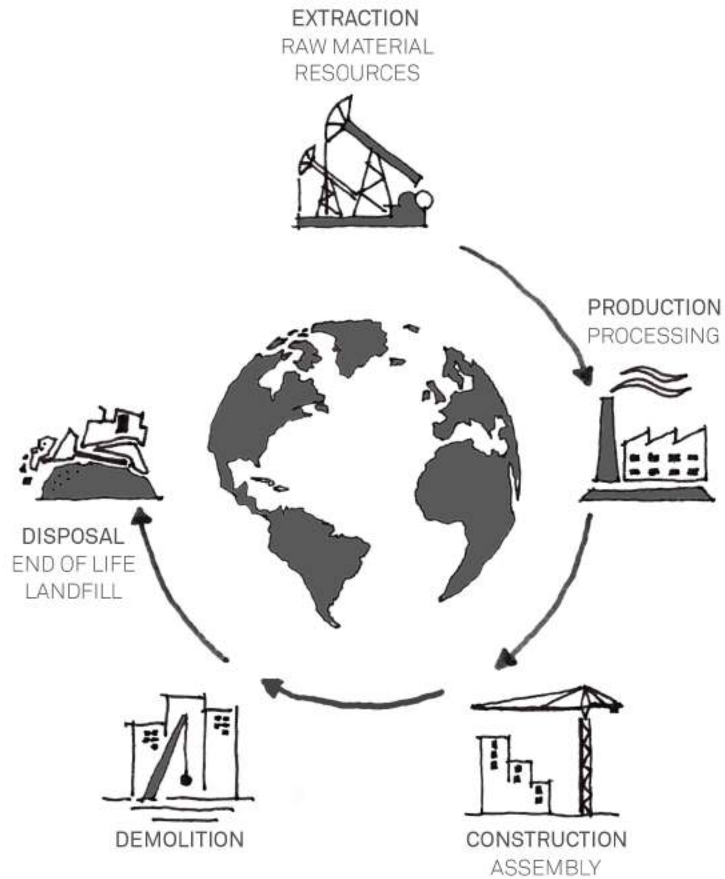
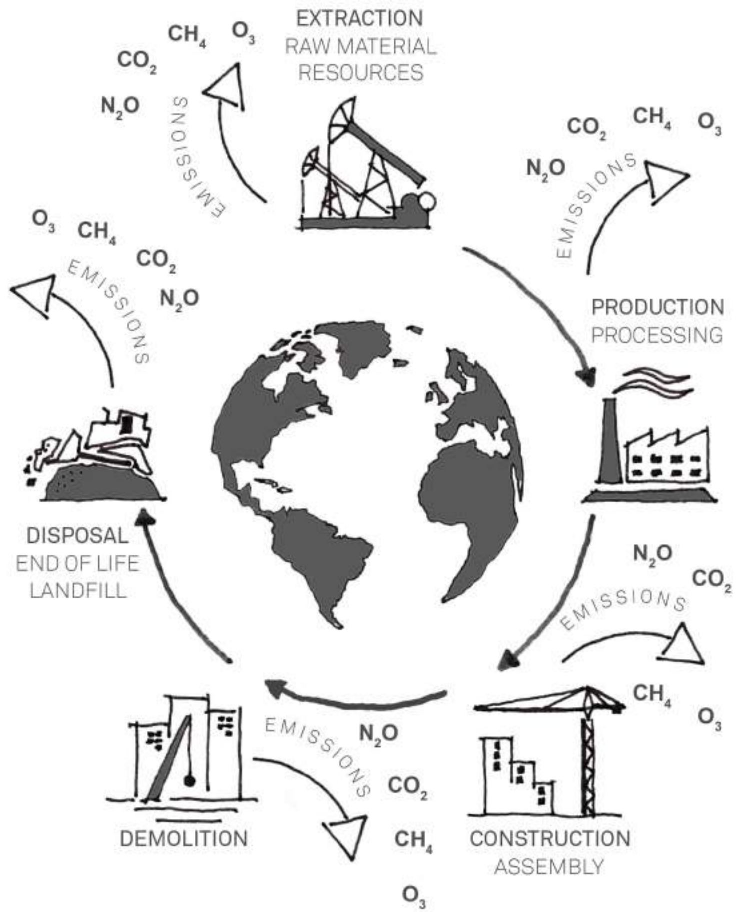
CRADLE TO GRAVE :
MATERIAL AND RESOURCE UTILIZATION

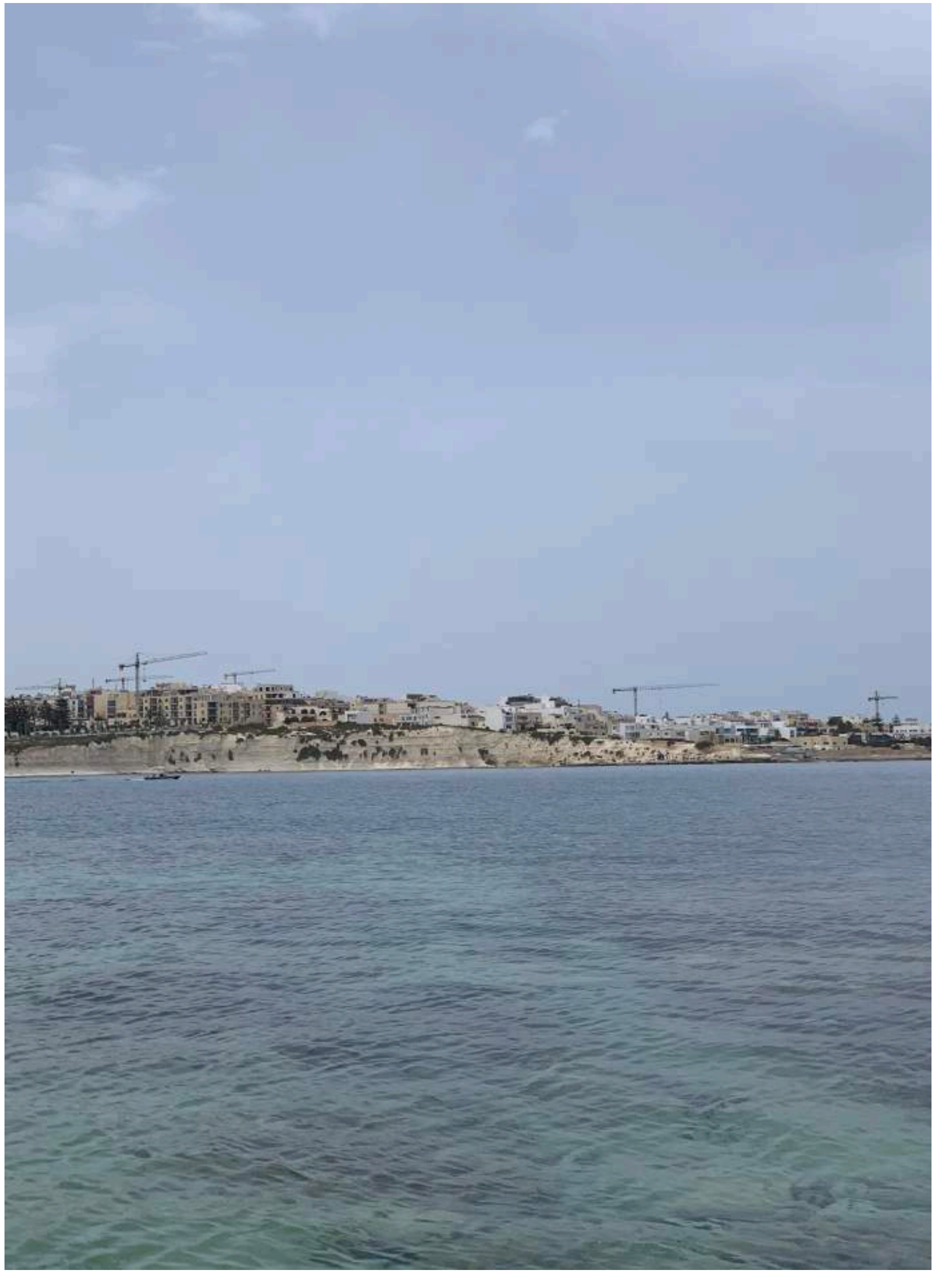


The linear 'take-make-consume-dispose' or Cradle-to-Grave economic model for material and resource use has become the predominant model of extractive construction activity. This model of consumption, based on the assumption that natural resources are available, abundant, easy to source and cheap to dispose of, has come to define our unsustainable geological era of the Anthropocene - the period during which human activity has been the dominant influence on climate and the environment.

CONSTRUCTION INDUSTRY = 40-50% OF GLOBAL GREENHOUSE GAS EMISSIONS



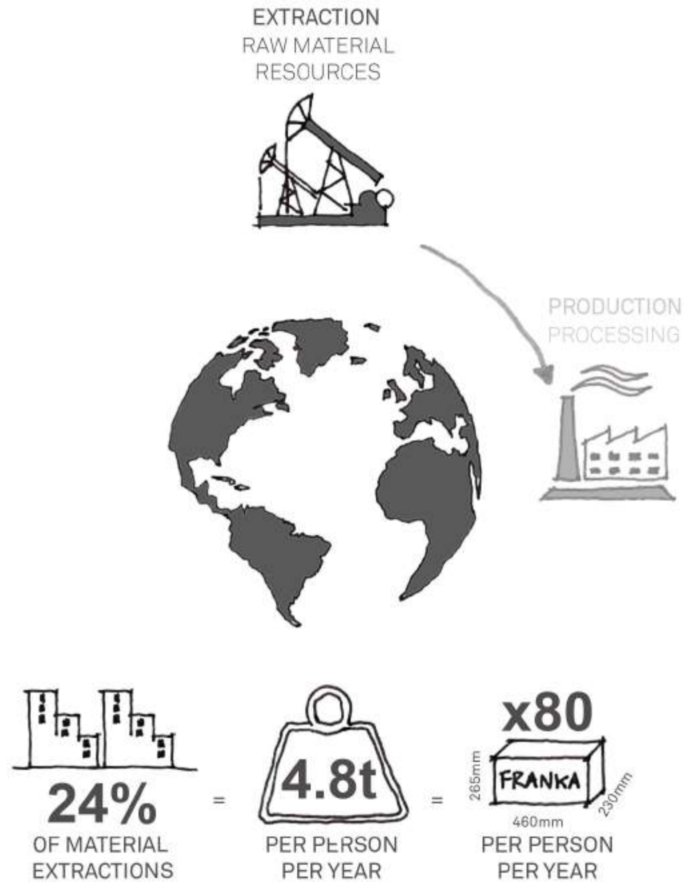
At every stage of the construction process, emissions of Greenhouse Gases are released into the atmosphere. Composed most significantly of carbon dioxide, methane, nitrous oxide and other fluorinated gases, these emissions have wide ranging and potentially destructive environmental and health effects. These gases not only trap heat within our atmosphere, raising the global earth temperature, but contribute to respiratory disease, smog from air pollution, drive extreme weather events and precipitate wildfires and disruptions in food production.



St Thomas Bay with six cranes in view from Munxar Path.
Photo: Author

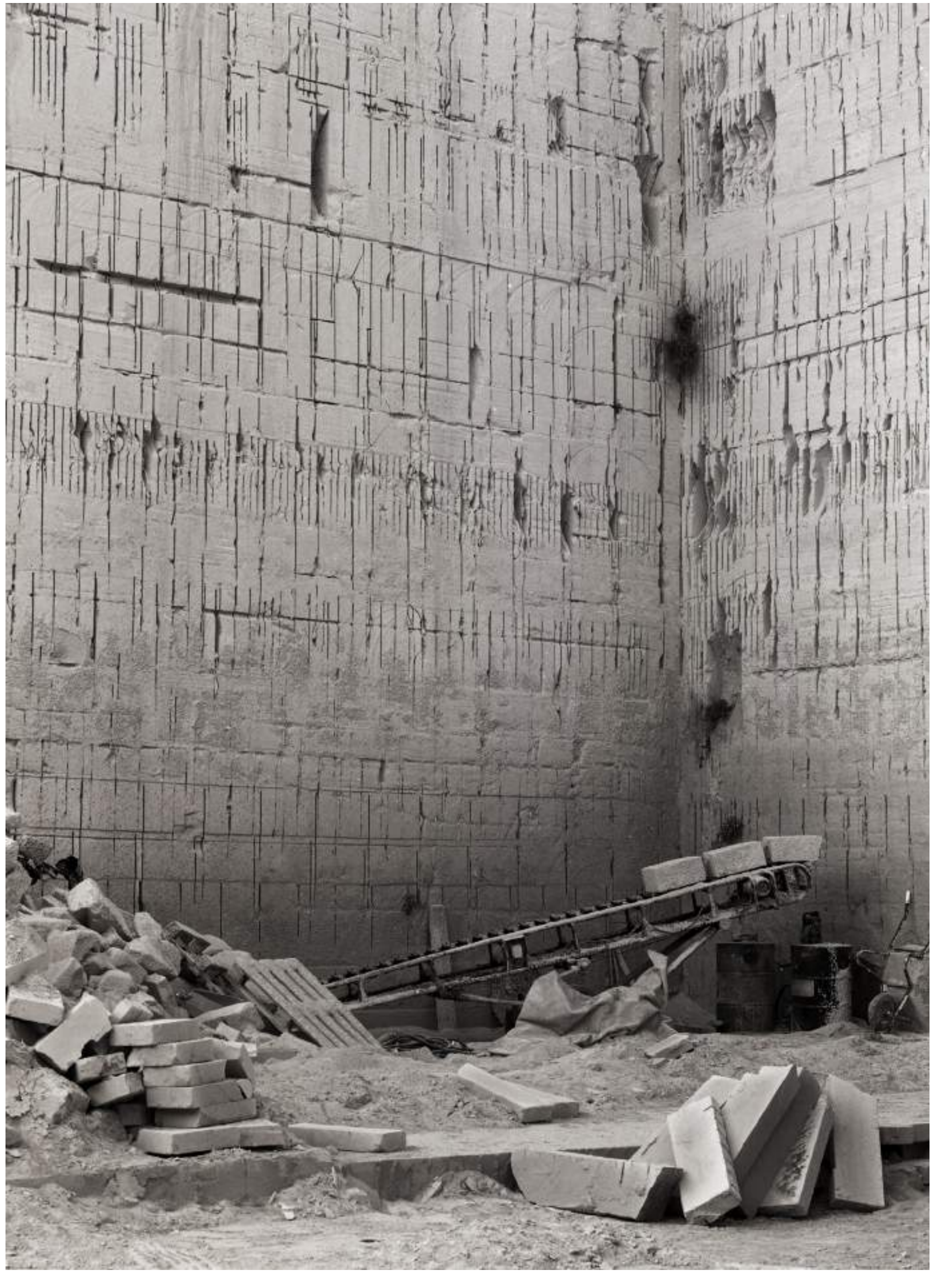
Demolition site in Madliena Heights.
Photo: Author

BUILDING CONSTRUCTION = 24% OF GLOBAL RAW MATERIALS EXTRACTED FROM THE LITHOSPHERE



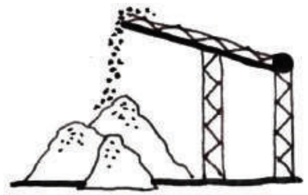
Globally the construction industry is responsible for 60% of all the raw materials extracted from the lithosphere - the rigid outer part of the earth consisting of the crust and upper mantle. From this volume, buildings consume around 40%, in other words, 24% of all global extractions. In Europe, the mineral extractions per capita intended for building amount to 4.8 tons per inhabitant per year - the equivalent weight of 80 typical limestone 'Franka' building blocks.

Exhausted quarry turned into landfill at the limits of Mosta and Naxxar.
photo: Julian Vassallo



Active quarry in Siggiewi
photo: Julian Vassallo

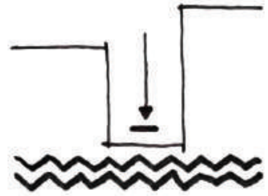
ALTHOUGH INHERENTLY A LOW CARBON RESOURCE, NATURAL STONE IS A FINITE MATERIAL - THE EXTRACTION OF WHICH POSES A UNIQUE SET OF ENVIRONMENTAL CONCERNS FOR MALTA



QUARRY WASTE

VISUAL IMPACT

NOISE / VIBRATION



PROXIMITY TO WATER TABLE

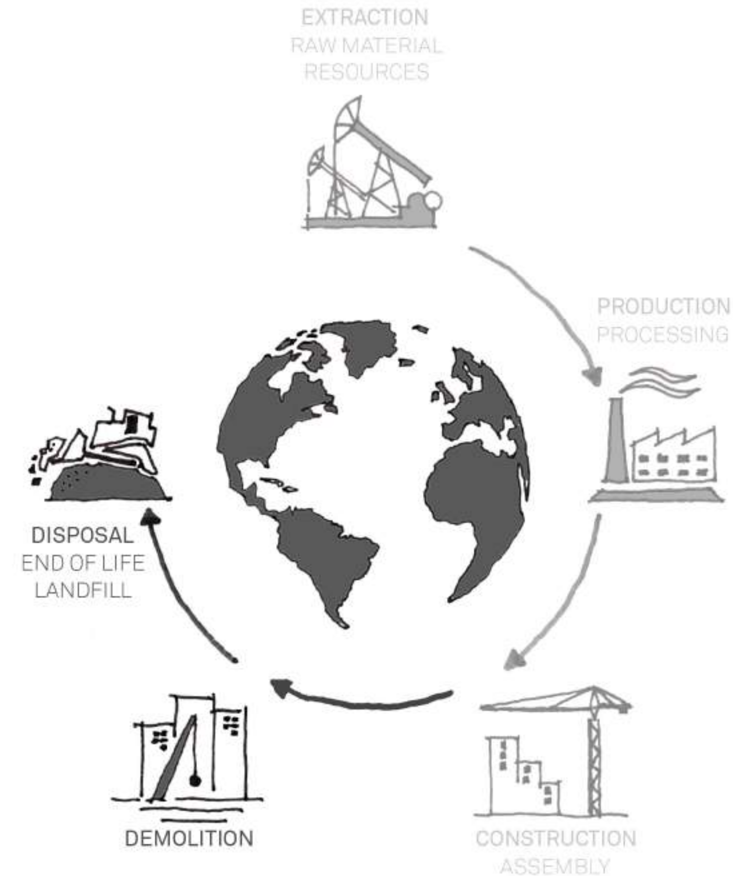
AIR / DUST POLLUTION

BIODIVERSITY LOSS

Limestone quarrying has sustained the Maltese building industry for centuries, however the environmental and health impacts of quarrying activities are significant. Predominant issues include: noise and vibration; visual impact; irreversible changes to landforms impacting biodiversity; and habitat loss. Most significantly however is the production of dust and by-waste material. A typical production rate at a quarry generates 900 stones per day with the resultant release of 351 kg of dust. Production wastage further varies from 50 % to 20 % depending on the geological features of the quarry. These processes not only pose risks in terms of respiratory health, but also exemplifies significant levels of finite material waste generation and loss of possible economic value.

 photo: Julian Vassallo

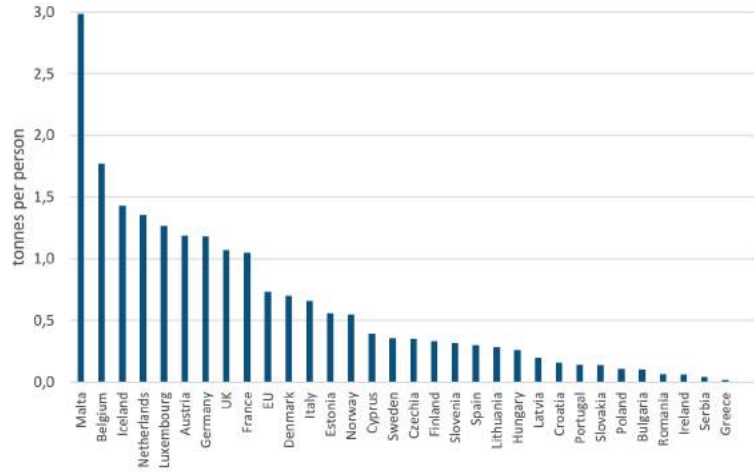
CONSTRUCTION & DEMOLITION WASTE = 1/3 OF ALL WASTE PRODUCED IN THE EUROPEAN UNION



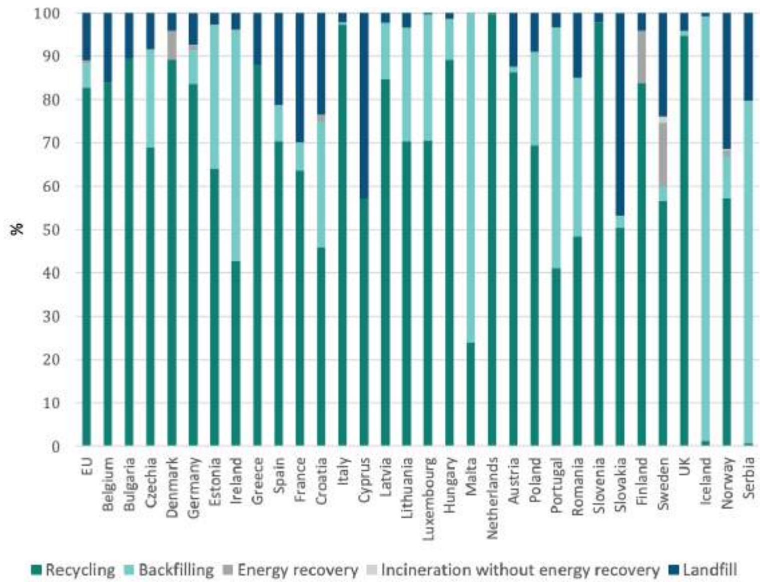
Construction and demolition waste (C&DW) is the largest waste stream in the EU by weight, with a reported 374 million tonnes generated in 2016 alone. C&DW has thus been defined as a priority area by the EU under both the Waste Framework Directive (2018) and the Circular Economy Action Plan (2015). As such, mandatory targets of waste recovery have been set with Member States encouraged to take appropriate measures to implement, among other things, the "production and marketing of products that are suitable for multiple use, that are technically durable and that are, after having become waste, suitable for proper and safe recovery and environmentally compatible disposal".

CONSTRUCTION & DEMOLITION WASTE IN MALTA = 2.9 TONNES PER PERSON PER YEAR, 70% OF WHICH IS ‘RECOVERED’ AS DOWNCYCLED LOW VALUE BACKFILL

Generation of construction and demolition waste, tonnes per person. source: eurostat 2019



Treatment of mineral waste from con-struction and demolition, source: eurostat 2019

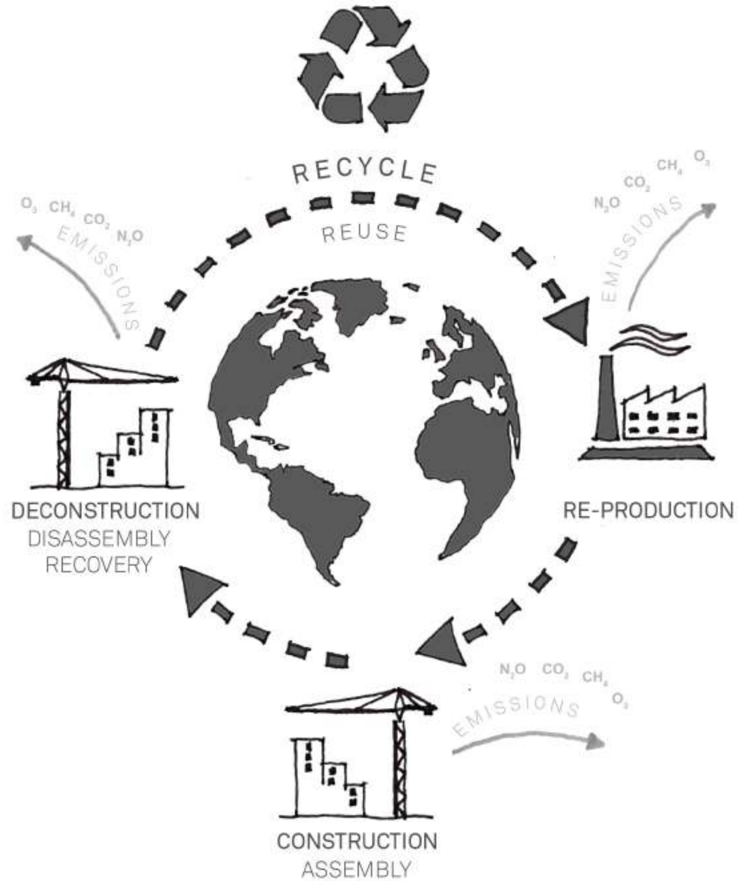


The recycling potential of C&DW, although high in quantitative terms, is still under-exploited. The mineral fraction of C&DW, for example, is currently mainly being recovered in road foundations or backfilled. This is exacerbated locally in Malta through poor management of backfill sites, with piles of deposited waste often piled high and spilling over into adjacent environments. Not only does this draw increased attention to the physical scars caused by the original quarries but further altars the condition of the ground by constructing evermore alien forms of landscape and terrain.

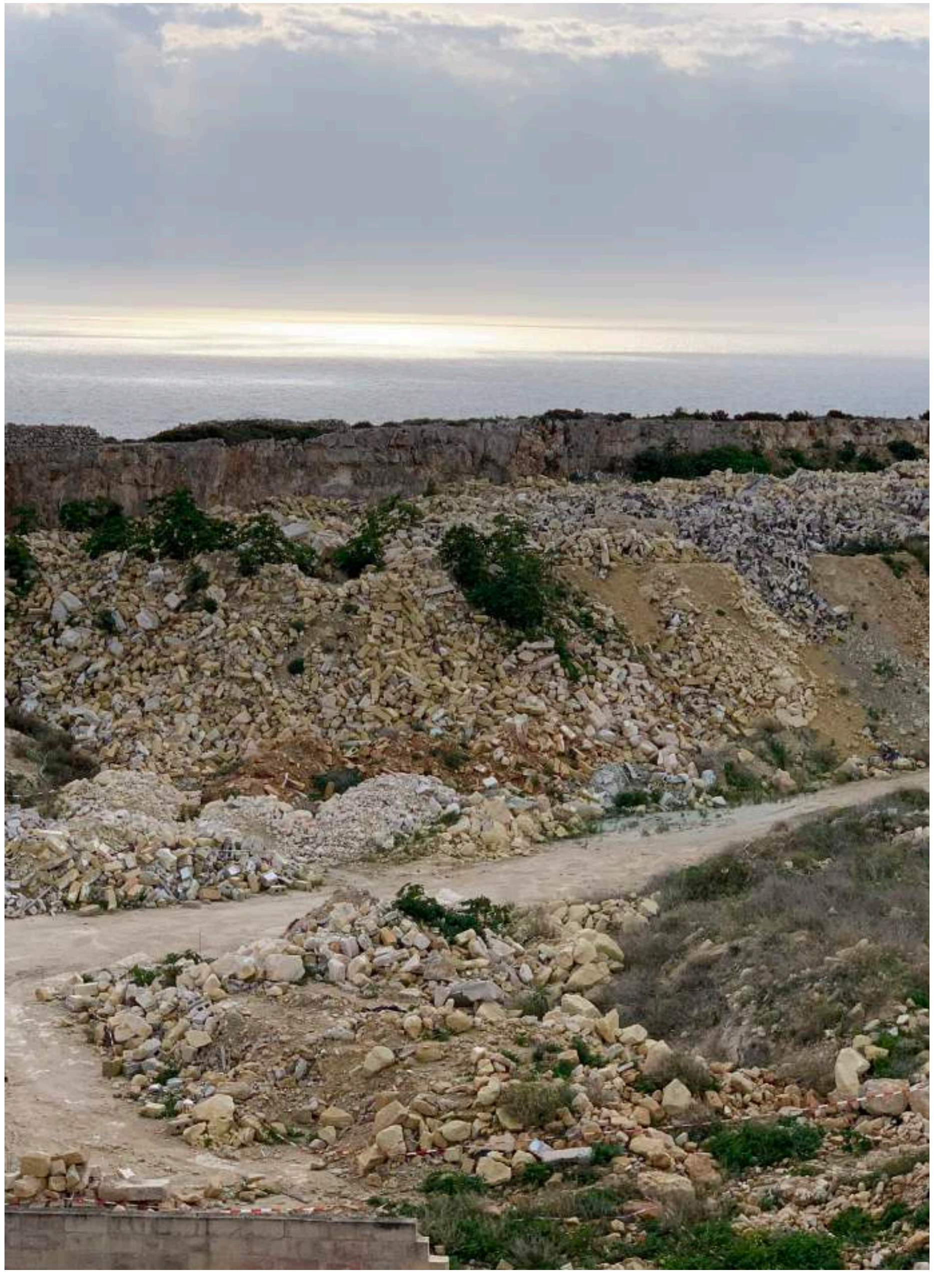
Backfill site at Wied Incita overflowing into neighboring property
photo: A.Collective

Location of underwater spoil site situated roughly 3.5km north-east of Valletta. A staggering 4.7 million tonnes of construction waste was dumped in the Maltese sea between 2004 and 2018

A CIRCULAR ECONOMY REQUIRES THE FUNDAMENTAL RETHINKING OF VALUE CHAINS AND THE ECONOMIC SYSTEMS IN WHICH THEY ARE APPLIED TO ACHIEVE THE LOWEST POSSIBLE ENVIRONMENTAL IMPACT.

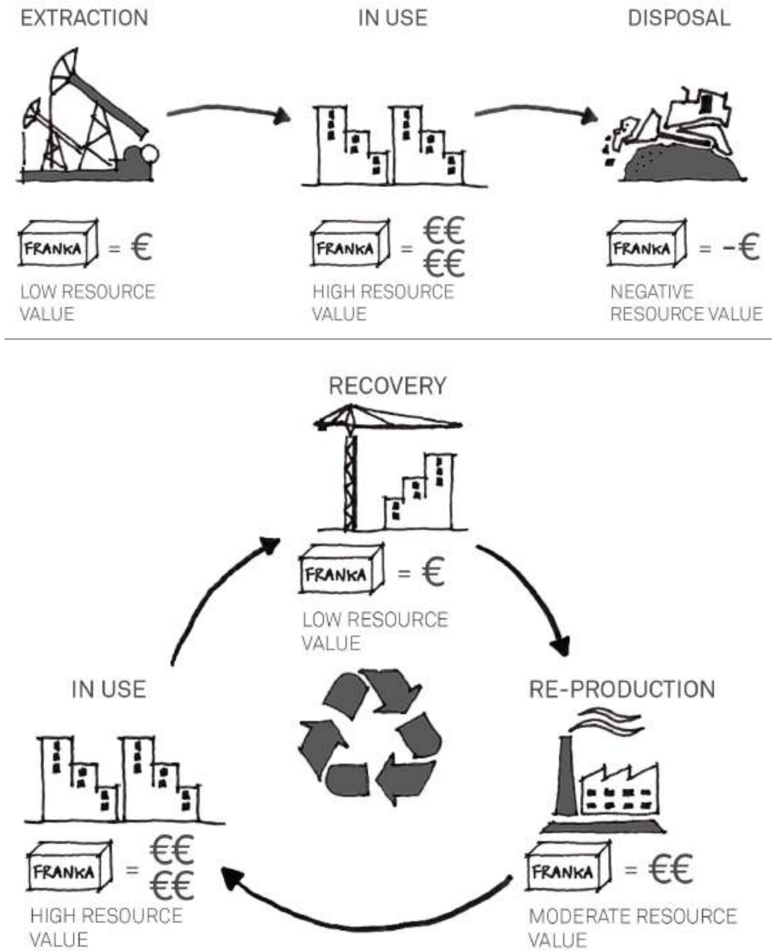


A circular economy represents a fundamental alternative to the linear 'take-make-consume-dispose' economic model. The circular economy is restorative in nature, and aims to maintain the utility of products, components and materials for as long as possible while also preserving their value through optimised reuse or high-grade recycling. It thus minimises the need for new inputs of virgin materials and energy, while reducing environmental pressures linked to resource extraction, emissions and waste management. This goes beyond just waste however and requires natural resources to be managed sustainably throughout their life cycles.



Uncoordinated backfill site in Siggiiewi
Photo: Author

CRADLE TO GRAVE VS CRADLE TO CRADLE : WASTE RESOURCE VALUE CHAIN



In a circular economy, raw materials are not taken out of their cycles, but remain in the economy for as long as possible through their efficient and innovative management. As opposed to a linear economic model, where significant resource value is lost at the disposal stage, a circular model aims to foster an economy that retains as much of the value of materials as possible, for as long as possible by optimising reuse or high- grade recycling. As such building materials or building elements should be quickly and efficiently recovered, resulting in high-quality materials remaining in a closed loop. This means that the quantity of recycling or reuse is no longer the only objective: the type of recycling and the avoidance of downcycling is crucial.

RE:STONE
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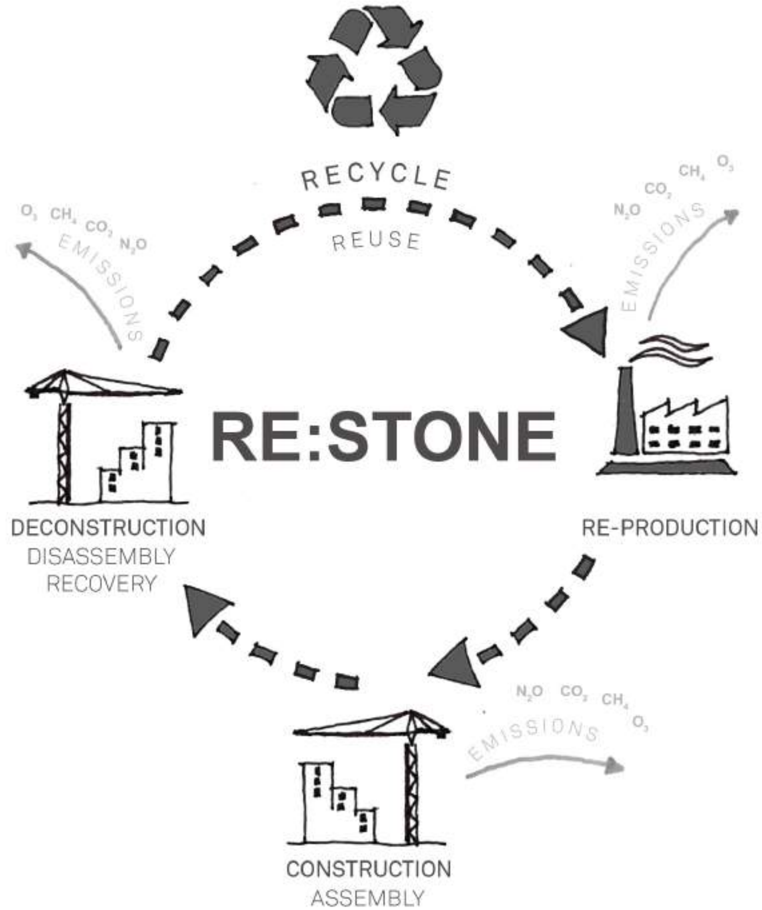
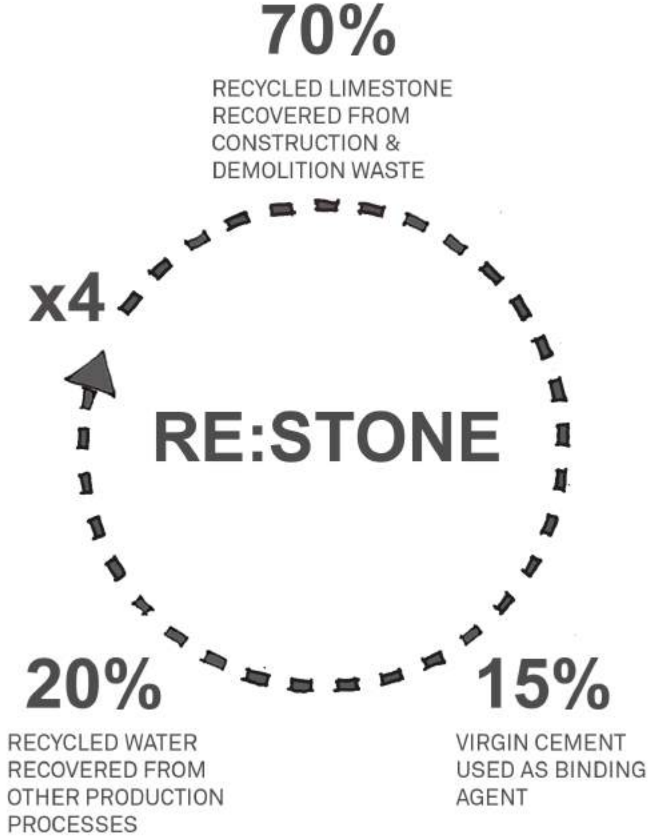
MATERIAL INNOVATION BASED ON A MODEL OF CIRCULAR CONSTRUCTION

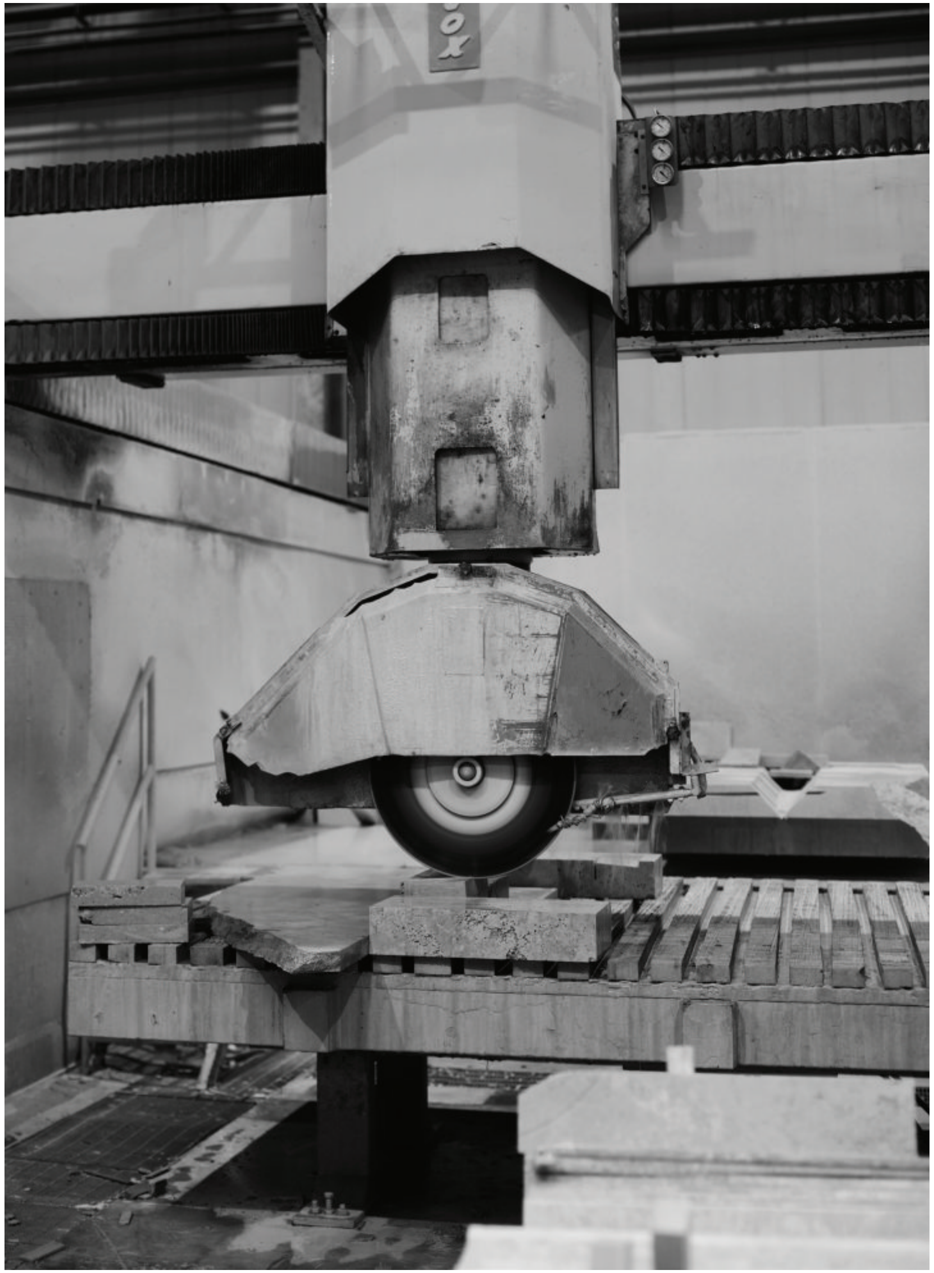


Developed by Profs S. Buhagiar at the University of Malta, Restone reconstitutes waste limestone building blocks or excavated limestone material into suitable building material. The process recycles waste limestone by processing waste aggregate into a suitably graded powder which in turn is converted into workable paste and moulded. The resulting reconstituted stone material is a hard, dense limestone which retains the golden hue of natural limestone and can be cut, shaped and finished in a similar manner.

'Restone' material sample for AKKA pavilion
Photo: Julian Vassallo



Restone stands as a model for the innovative and sustainable use of waste in high-grade recycled material products. Utilising up to 70% recycled limestone, Restone absorbs mineral construction and demolition waste into a material loop which has the potential to significantly reduce the demand for virgin material production and subsequent generation of waste for disposal. This type of recycling also aids in retaining the inherent material value by preventing downcycling into low-grade construction materials such as aggregates for infrastructure projects.



AKKA pavilion production process
Photo: Julian Vassallo

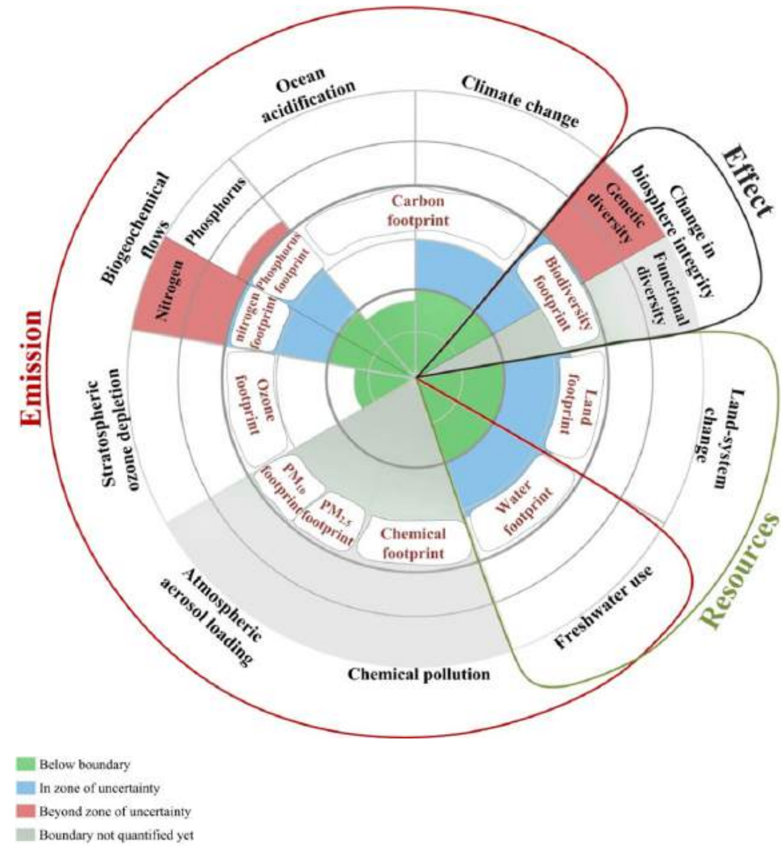
AKKA pavilion production process
Photo: Julian Vassallo

ENVIRONMENTAL FOOTPRINT OF RE:STONE

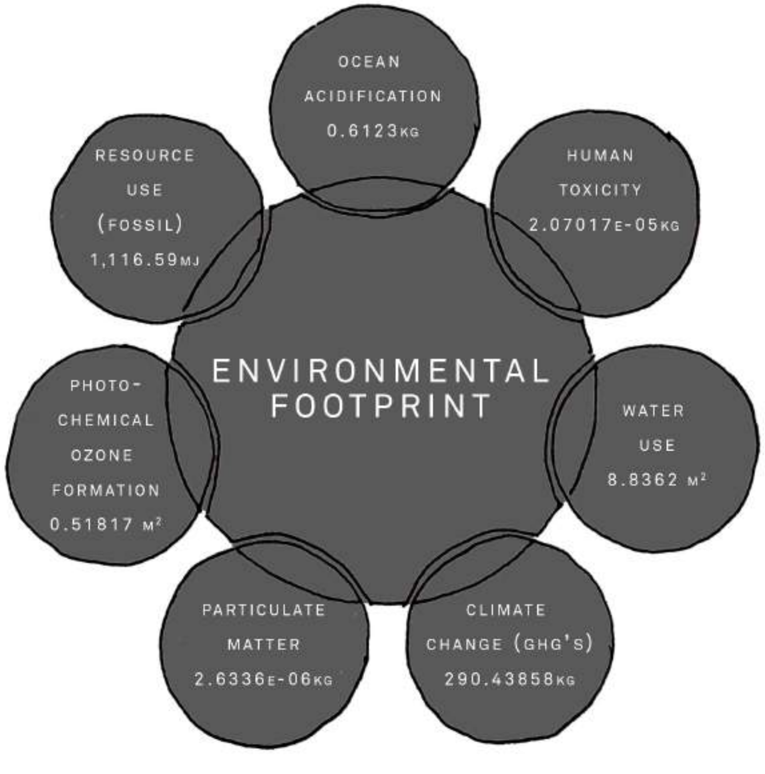
AKKA pavilion module
Photo: Julian Vassallo

An environmental footprint analysis helps to identify the linkages between human and natural systems, and provide a framework of indicators that can be used to evaluate the pressure of human activities on the environment.

AN ENVIRONMENTAL FOOTPRINT IS A MULTI-CRITERIA MEASURE TO CALCULATE THE ENVIRONMENTAL PERFORMANCE OF A MATERIAL, PRODUCT, SERVICE OR ORGANISATION BASED ON A LIFE CYCLE APPROACH



Environmental footprint data can be viewed in relation to the nine planetary boundaries defined by the European Environment Agency as shown in Rockstrom et al's 2016 'current status' diagram above. These planetary boundaries include, climate change, rate of biodiversity loss, interface with nitrogen and phosphorus cycles, stratospheric ozone depletion, ocean acidification, global freshwater use, change in land use, chemical pollution and atmospheric aerosol loading. Planetary boundaries define a safe operating space for humanity and the related limits which need to be respected to avoid major and potentially irreversible changes within the earth systems.



Environmental Footprint analysis of typical Restone block.

The main environmental impacts from the Restone material arise from the use of cement as a binder. It is important here to consider that researchers are currently developing alternative binding agents which require far less energy use in their production when compared with cement. This shift in material composition would undoubtedly positively alter the current environmental footprint of Restone.

Overall 'Climate Change' is the largest impact boundary contributing 290.44 kg of GHG emissions per typical Restone block. Carbon dioxide accounts for 283.78 kg, followed by methane with 0.12745 kg. Resource Use (fossil), refers to consumption of crude oil (524.88MJ), hard coal (238.03 MJ) and natural gas (136.19 MJ), followed by uranium (122.57 MJ), brown coal (94.27MJ) and peat (0.65MJ). These impacts are typically incurred due to the burning of fossil fuels required to provide energy at all stages of the production of cement.

This production consists of raw materials such as limestone, chalk, shale, clay and sand which are quarried, crushed, finely ground and heat processed to the correct chemical composition. These processes are highly energy intensive leading to the cement production industry contributing between 8 - 10% of all anthropogenic Greenhouse Gas (GHG) emissions.

Whilst the environmental impact of cement use could be considered significant, Restone is also composed of 70% recycled limestone which, given current 'recovery' practices in Malta would have otherwise been backfilled into an exhausted quarry, dumped at sea or used as low value aggregate for construction. The reuse of this material thus greatly reduces (and potentially eliminates) the need to extract new virgin limestone blocks for construction.

Restone then not only presents a clear opportunity to integrate 'waste' material back into a high value production / construction cycle, promoting a model of circularity within the Maltese construction industry, but also has the potential to dramatically reduce atmospheric particulate matter (dust generation) and its effects on human health due to the decline in impacts associated with quarrying practices. In the case of Malta, particles of this nature are of serious concern given a recent report by Fenech and Aquilina (2021) which identifies curent concentrations as being very close to the limit set by the EU Air Quality Directive and exceed that set by the World Health Organisation.

AKKA pavillion by A.Collective

photo: Julian Vassallo

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