Superuse and upcycling *through* design. Approaches and tools

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SBE19 Brussels BAMB Circpath Conference | 07 February 2019

BAMB BUILDING AS MATERIAL BANKS
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 642384.

Contents

- Italian current situation with reference to C&D waste
- Italian GPP policies as a first approach to circularity in the built environment
- National experiences of designing and building with waste materials_ ARCò
- Facing the main national challenge in the C&D waste management: upcycling inert waste _ Atlante Inerti Project
- Superuse design approach: application of the harvest map tool in Italy

  _ Superuse refurbishment of a Villa in the northern lakes district

  _ A harvest map for the urban regeneration of a former industrial site in Rome
- Conclusions and outlook _ Circular District Tiburtino feasibility study

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Italian current situation with reference to C&D waste

- In Italy, the renovation and substitution of existing buildings, not conceived to be easily deconstructed, generates 53 million tons/year of C&D waste [ISPRA 2017 *Rapporto Rifiuti Speciali* 264]
- The same quantification of C&D waste produced each year suffers a recognized uncertainty [*Rapporto Italia del Riciclo*, https://www.fondazionesvilupposostenibile.org] due to a non-widespread data collection on the national territory, which leaves out small volumes, often illegally managed
- Almost 80% of C&D waste is mixed inert waste
- The recovery rate is still limited, especially within the building value chain:

  recycled aggregates (about 70%) are mainly used in road works and environmental recoveries and, only to a very limited extent (3%) in constructions (fillings, bases)
- Recycling is widely applied to other fractions (metals, glass, plastics), as well as to wooden components and gypsum board (Gyproc return to producer scheme)
- Reuse is constantly implemented in restoration to traditional materials, but not for new materials and components.

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Italian GPP policies as a first approach to circularity in the built environment

- Italy is the first EU Country to have made GPP (Green Public Procurement) 100% mandatory in sectors implying energy uses, including construction
- Adoption of Minimum Environmental Criteria (CAM) for Buildings within the National Action Plan for GPP (DM 24/12/2015 and update DM 11/10/2017) made mandatory by Law 221/2015 and by the New Procurement Code (D.Lgs 50/2016)
- CAM contain an articulated series of criteria, including a set of rules promoting the closed-loop use of building materials for both renovation and new construction of public buildings:
  - use of a minimum recycled content of 15% on the total weight of the materials used (5% for concrete elements)
  - design for deconstruction applied to at least 50% of buildings components used in the intervention
  - 70% diversion from landfill of generated C&D waste
  - pre-demolition audits
  - reuse of stone and mixed (stone and bricks) masonry for foundation and elevation works.

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Italian GPP policies as a first approach to circularity in the built environment

- CAM establish a set of measures strictly related to the objective of Resource Efficiency, among a wide range of energy and eco-compatibility targets
- The mandatory recycled content is still a limited target → lack of consideration of the higher value obtainable from the reuse of materials
- Even though not systematically applied yet, this mandatory tool is helping to start a radical change in the construction industry

Example

EPR (Extendend Producer Responsibility) model

Developer

Centro Materia Rinnovabile, a private research and communication institution collecting the main construction industry stakeholders

Goal

creating a "Collective Construction System" by promoting normative and other tools which could help applying circular practices in the building sector.

Source: Centro Materia Rinnovabile

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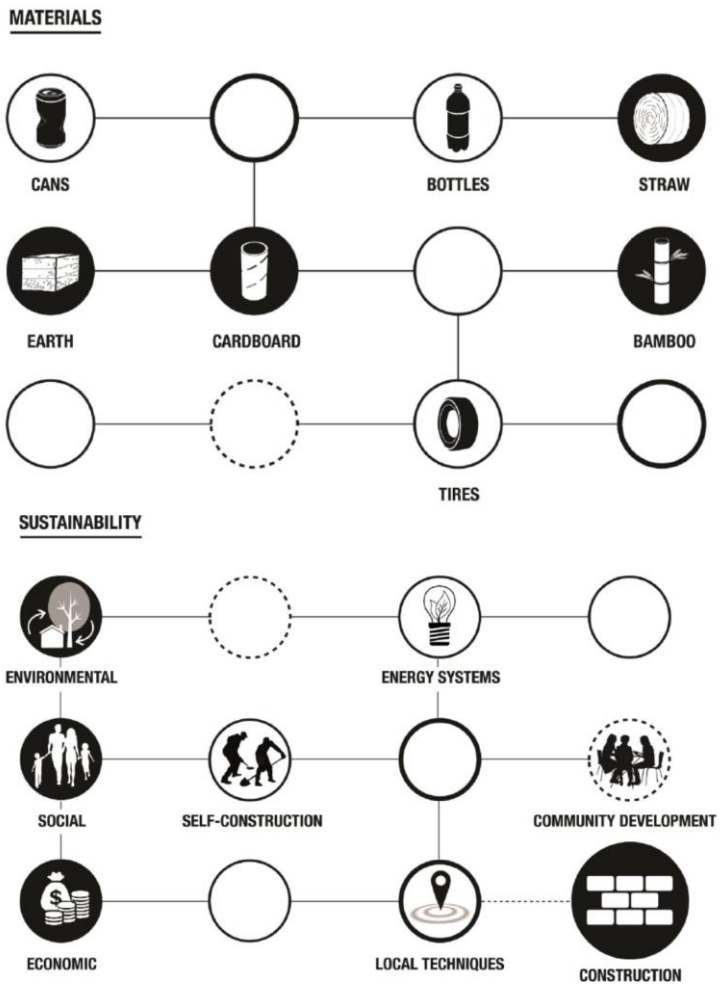
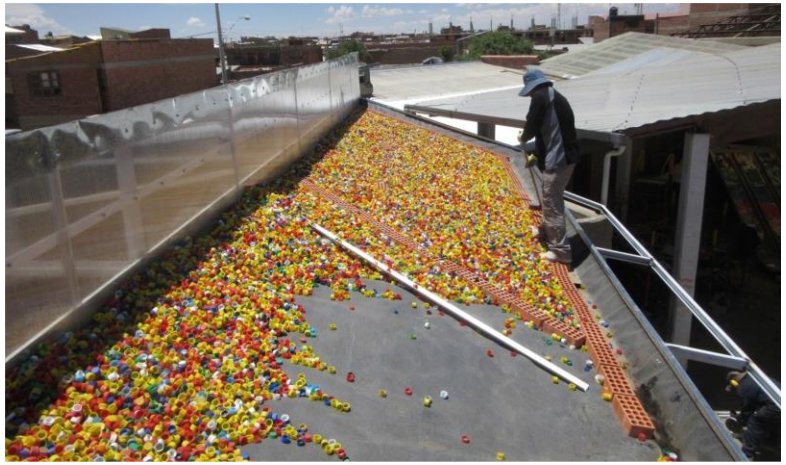
National experiences of designing and building with waste materials: ARCò

ARCò – Architecture and Cooperation



Renovation of an orphanage | Bolivia 2014
Green roof base with reused plastic caps



Photos, courtesy of Alessio Battistella, ARCò

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ARCò | Casa Chiaravalle, secondary use of reclaimed materials plus earthbags

Casa Chiaravalle, Milan (Italy) | June 2018

- Developed within the *Design and Build with Økm (local and recycled materials) Workshop,* EU Erasmus+ Project BIØN (Building Impact Zero Network)
- Realization of a 1:1 object inside the complex of Casa Chiaravalle, a place confiscated from the organized crime that in the next future will become a reception center for immigrants.

Photo, courtesy of Alessio Battistella, ARCò

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ARCò | Casa Chiaravalle, secondary use of reclaimed materials plus earthbags

- Use of a pre-existing wooden frame
- Team enrolled students, migrants, NEET, unemployed, architects, engineers, coordinated by ARCò, in a four-week training and hands-on experience
- Use of the building techniques of *earthbags* and *earthship*, with natural and upcycled waste materials (reclaimed windows and wooden frames, glass bottles, plexiglas panels, pallets)
- Search for appropriate technologies with little processing or transporting and low environmental and economic costs (5,000 €)
- Creation of a space for a discussion on the local sustainability exploring the potential of alternative and low cost building techniques.

Photos, courtesy of Alessio Battistella, ARCò

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to, courtesy of Alessio Battistella, ARCò

Research Team's approach and research focuses

Goal

Increase of resource productivity in the National building sector

Focuses

1. Facing the main criticality (in terms of quantity) consisting in the failure to reintroduce inert waste in the building sector as building materials or products

UPCYCLING

The practice of recycling material in such a way that it maintains and/or accrues value over time

2. Integrating adaptive reuse of existing buildings (a widespread practice in the Country) with superuse of components and materials, a strategy inherent to the preservative Italian approach, preferable to recycling according to the EU Waste Hierarchy (EU Dir. 98/2008), but still underestimated by Italian legislation

SUPERUSE

Search of discarded materials, aiming to identify their reuse potentialities and turn their features into an added value for new products/buildings

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R&D ON RECYCLED AGGREGATES AND DESIGN OF NEW PRODUCTS

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SUPERUSE

TESTING TOOLS SUCH AS HARVEST MAP AND SUPERUSE FEASIBILITY

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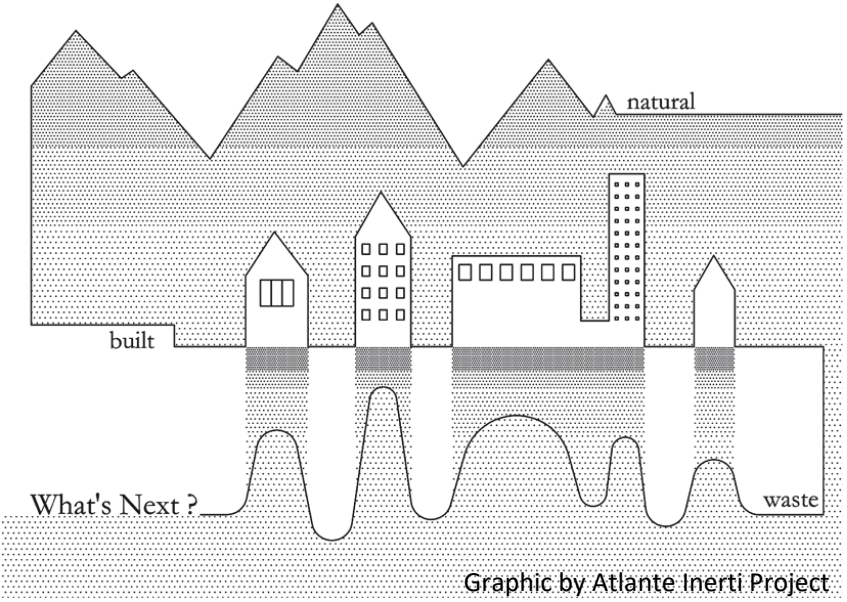
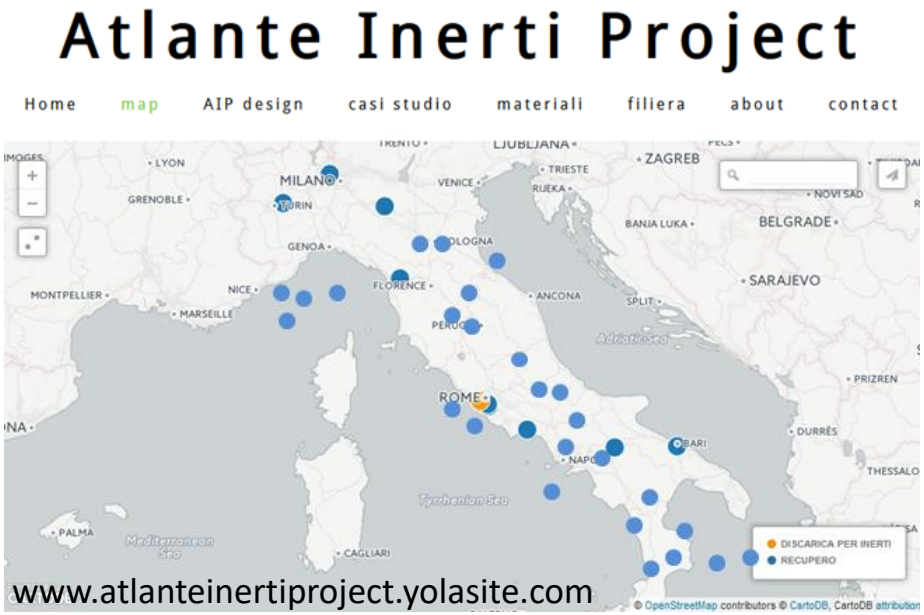
Upcycling inert waste | Atlante Inerti Project

- Information, research and development project started in 2013 from which a business project derives, with the aim of promoting innovative uses of recycled aggregates
- Development of a geo-referenced map of certified aggregates suppliers in the national territory, drawing attention to the supply (recycling plants) and encouraging the meeting with demand (industries, construction companies) through networking activities
- First specific database in Italy and derives from an international benchmarking activity
- *Team:* Architects Paola Altamura, Giulia Chiummiento, Massimo Cutini



Graphic by Atlante Inerti Project



www.atlanteinertiproject.yolasite.com

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AIP| Large scale 3D additive printing (D-Shape) with recycled sand

Since 2016, AIP has undertaken design and prototyping activities on concrete products with the exclusive use of recycled aggregates, identifying the most suitable standard and innovative technologies for an unprecedented experimentation in Italy.

- experimentation phase with the a large scale 3D printer, used for the first time by AIP with a 100% recycled sand from C&D
- characterization of the innovative concrete carried out with experimental tests developed by the CertiMaC Laboratory in Faenza (ENEA, CNR)
- evaluation and comparison of the mechanical resistance levels achievable with the printing technique applied to recycled aggregates with two different binders (cement and magnesium)
- results showed that the magnesium binder, preferable from the environmental point of view (limited content of embodied energy), proved to be less efficient than cement in terms of mechanical properties (magnesium bonded concrete, compressive strength of 7 MPa; cement bonded concrete, 25 MPa). The second mix has a medium-high strength class (C20/25, NSC - Normal Strenght Concrete) and can be used for different types of non-structural products.

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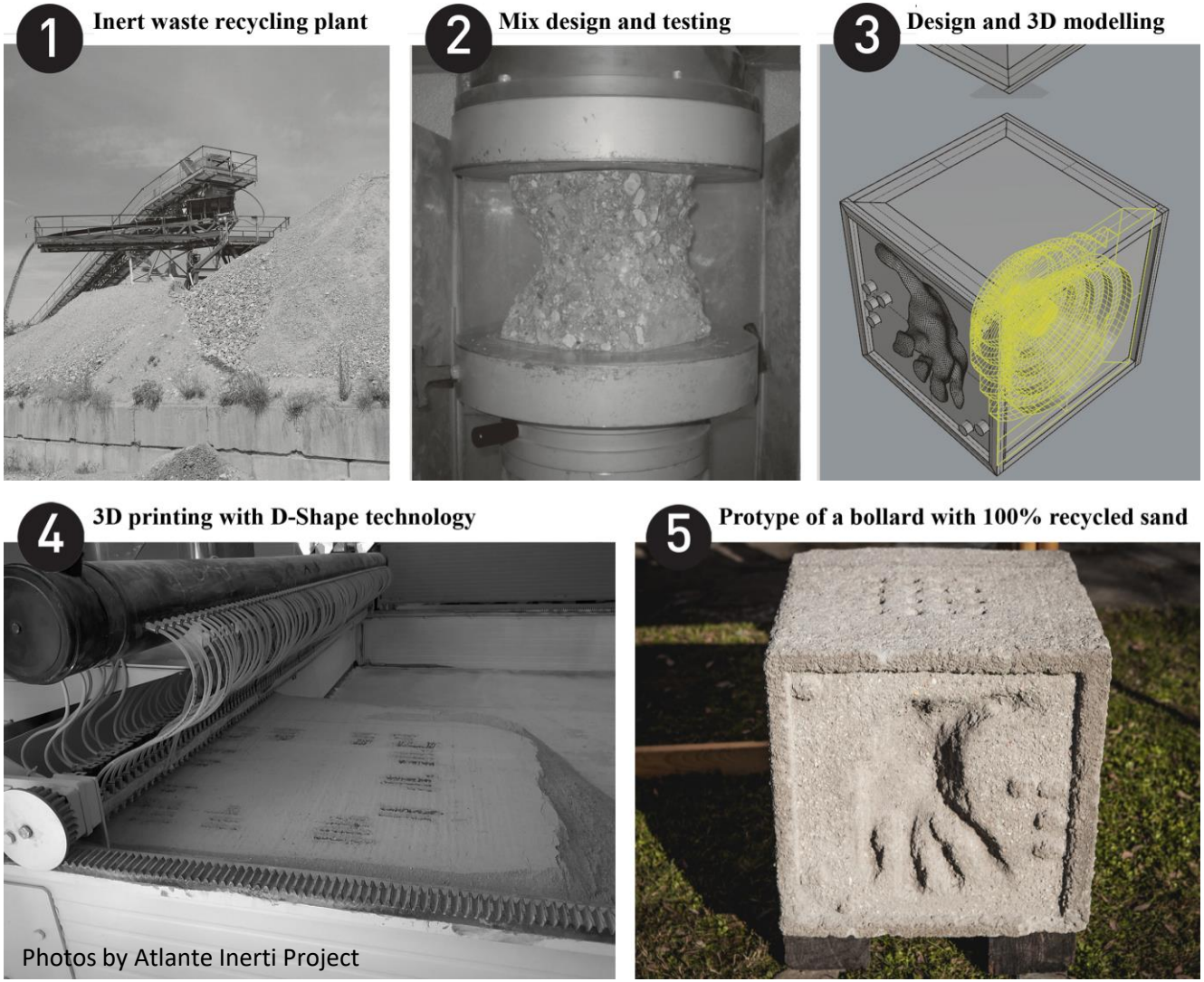
AIP| Large scale 3D additive printing (D-Shape) with recycled sand

AIP created a prototype (cubic with a side of 60 cm, as a bench or a bollard) designed to test the technical and aesthetic performance of the recycled concrete with cement binder: convincing result in terms of aesthetics and performance, though the duration and costs of the production technique are still too high due to the level of technical development of the printer.



Photos by Atlante Inerti Project

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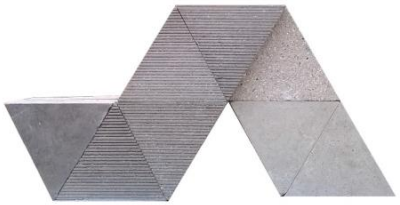
AIP | Vibrated precast recycled concrete modules for outdoor use

AIP then developed a system of outdoor modular furniture pieces with conventional concrete vibro-compression techniques, which were tested (with the technical support of Conselab Srl) and prototyped, currently ready for industrialization (Project *System-T Ricoeso*, based on a packed bag of recycled sand developed by a roman recycling facility).

Photos and graphic by Atlante Inerti Project

SISTEMA
T-ricoeso



AIP

Atlante Inerti Project
atlanteinertiproject@gmail.com

CONSELAB CONSULENZA LABORATORIO

Conselab srl
www.conselab.it

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Upcycling inert waste | Atlante Inerti Project

Summary of the results of the tests carried out on 4 samples of concrete produced using cement (binder) and 0-4 mm recycled sand.					
	U/M	MIX 01	MIX 02	MIX 03	MIX 04
Recycled aggregate (0-4 mm sand)	Kg	1.385	1.307	1.295	1.170
Cement 42,5 R	Kg	325	525	335	531
Additive	Kg	5,3	8,5	7,2	11,5
Water	Kg	166	167	194	202
Water - cement ratio	%	0,51	0,32	0,58	0,38
Voids	Lt	79	46	88	160
Density	kg/m3	1.881	2.008	1.831	1.915
Spreading	mm	250	210	400	420
Compressive strength (100 mm concrete testing cube)					
1st day	MPa	3,2	11,6	2,9	9,1
2nd day	MPa	6,3	17,6	3,1	14,6
3rd day	MPa	8,1	18,5	6,3	17,9
4th day	MPa	8,9	19,2	6,7	19,1
7th day	MPa	11,2	27,8	9,9	23,6
14th day	MPa	14,7	32,8	12,8	24,7
28th day	MPa	16,5	34,5	13,8	26,2
Compressive/Bending strenght (160x160x40mm concrete testing parallelepiped)					
Bending strenght - 28th day	MPa	3,5	5,1	2,4	4,6
Compressive strenght - 28th day	MPa	16,7	29,6	12,7	26,6

Source: Baiani S., Altamura P. (2018), "Waste materials superuse and upcycling in architecture: design and experimentation", in TECHNE, vol. 16, pp. 142-151, ISSN 2239-0243, http://www.fupress.net/index.php/techne/article/view/23035

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Graphic summary of the System T-Ricoeso project, by AIP

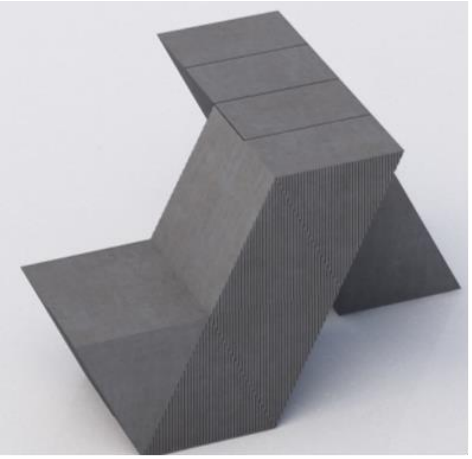
2016 | Co-founded by

Climate-KIC | Italy

2017 | AIP awarded *Maker of Merit*

ROME Maker Faire THE EUROPEAN EDITION

Upcycling inert waste | Atlante Inerti Project



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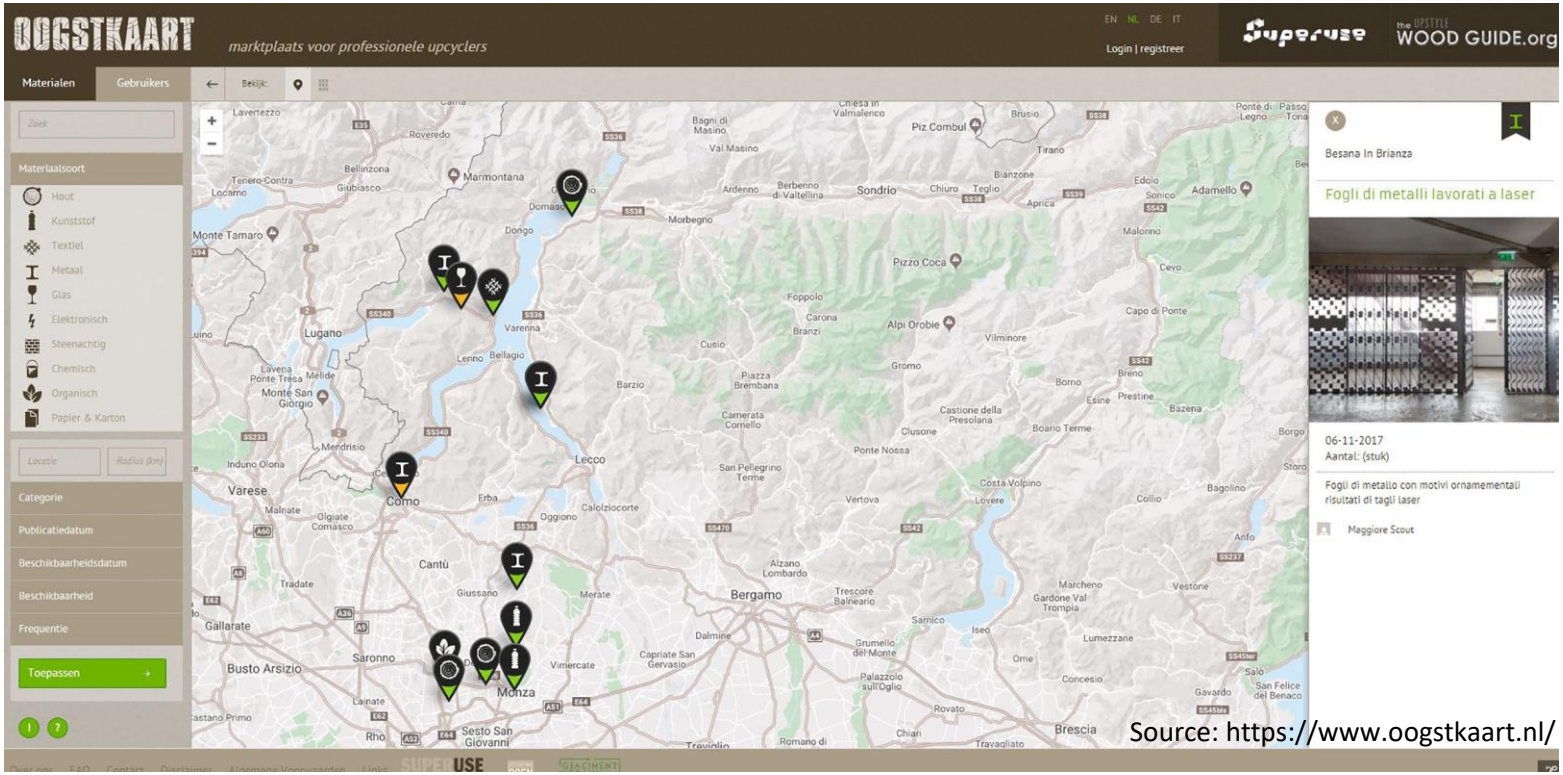
Superuse design approach: application of the harvest map tool in Italy

Superuse Studios' Harvest Map tool

Web GIS maps for sharing local resource flows for architecture:

- The design process should start with the scouting of materials, including any wasted material, component, product suitable for use in architecture (by-products, defective products, dead stock, leftovers, processing waste, C&D waste, etc.) available in the area adjacent to the intervention site, within a limited distance - on average a radius of 25 km.



Source: https://www.oogstkaart.nl/

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Superuse refurbishment of a Villa in the northern lakes district

Collaboration of the RT with architect Césare Peeren from the Dutch atelier Superuse Studios in the restoration of a listed building (a private Villa) in the northern lake district in Italy, started in September 2017 and completed in October 2018:

- Preliminary geographic based researches and following surveys, by a multidisciplinary team, for the selection of potentially interested companies and the identification of the flows of resources not reintroduced in the production cycles of the same or of other companies
- Database of available resources (waste category, type of material, size and frequency of production, price)

The Villa; Césare Peeren during research activities at the Villa; leftover metal panels found at a company in Pozzo d'Adda, Milan.

Photos by Paola Altamura

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Superuse refurbishment of a Villa in the northern lakes district

Selection of components suitable for use as integrative layers of the envelope and the vertical and horizontal partitions of the building and/or as components and materials for finishes and furnishings:

- fabric processing waste (defective silk and textile selvages)
- by-products derived from laser cutting of metal sheets
- surplus production of metal sandwich panels
- disused textile machinery with various metal profiles
- waste from the production process of mortars/resins for architectural finishes.

Design and construction workshop with Dutch and Italian teams (14 international designers).

Details from the Cloak room wardrobe by Studio Cifra during and after the workshop, photo by Denis Guzzo Source: VILLA MAGGIORE press release, https://re-use.eu/

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Superuse refurbishment of a Villa in the northern lakes district

The reuse of finishing mortars was developed in collaboration with Stefano Mereu, the producer of a mono-component water based resin for floors and walls, called "Malta" (mortar)

- product characterized by particular attention to ecological sustainability in the whole process of manufacturing, production, application
- compared to standard resins, the two layers composing the finishing are made of one-component water based polymers with very low VOC emissions in the drying phase (52 compared to 104 which is the maximum by law)
- once dried, it is VOC free
- production process with no CO2 nor other harmful emissions, based on an auto-ignition chemical reaction
- use of locally sourced raw materials.

Testing the reuse of leftovers of Malta, photo by Paola Altamura

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Superuse refurbishment of a Villa in the northern lakes district

Testing the reuse of leftovers of Malta with Stefano Mereu, photo by Paola Altamura

Reuse of different colored maltas in one the of bathroom of the Villa, photo by Paola Altamura

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The Villa's living room with the "Firehosescape" by Co2RO, photo by Denis Guzzo
Source: VILLA MAGGIORE press release, https://re-use.eu/

A harvest map for the urban regeneration of a former industrial site in Rome

The first application of the harvest map to the city of Rome concerned the area of the former industrial site Papareschi in the Ostiense - Marconi district, within a Thesis conducted with the Polytechnic University of Turin, Italy. The project, aimed at the regeneration of the former Miralanza factory with the reuse of building materials and industrial waste sourced on site, applied this process: materials *scouting* phase, creation of a *harvest map*, redefinition of functions and spaces, technological project of reversible building components with reclaimed materials.

Source: D'Alessandro E. 2018, *MI.REUSE, regeneration design of a former industrial site in Rome by components and materials from reusing processes*, Master's Thesis, mentor Giordano R, co-mentor Baiani S and Altamura P, available at: https://webthesis.biblio.polito.it/8303/.

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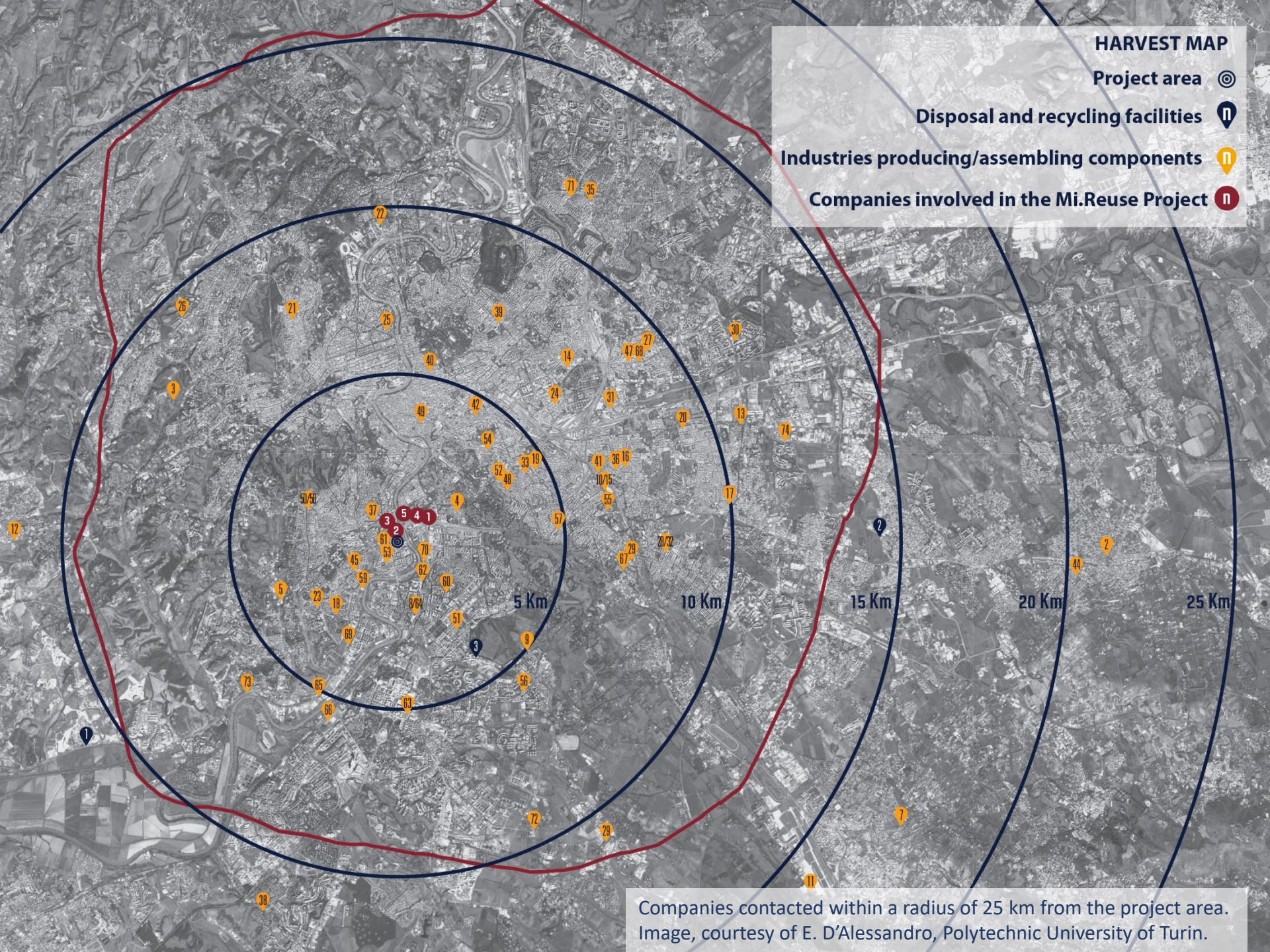
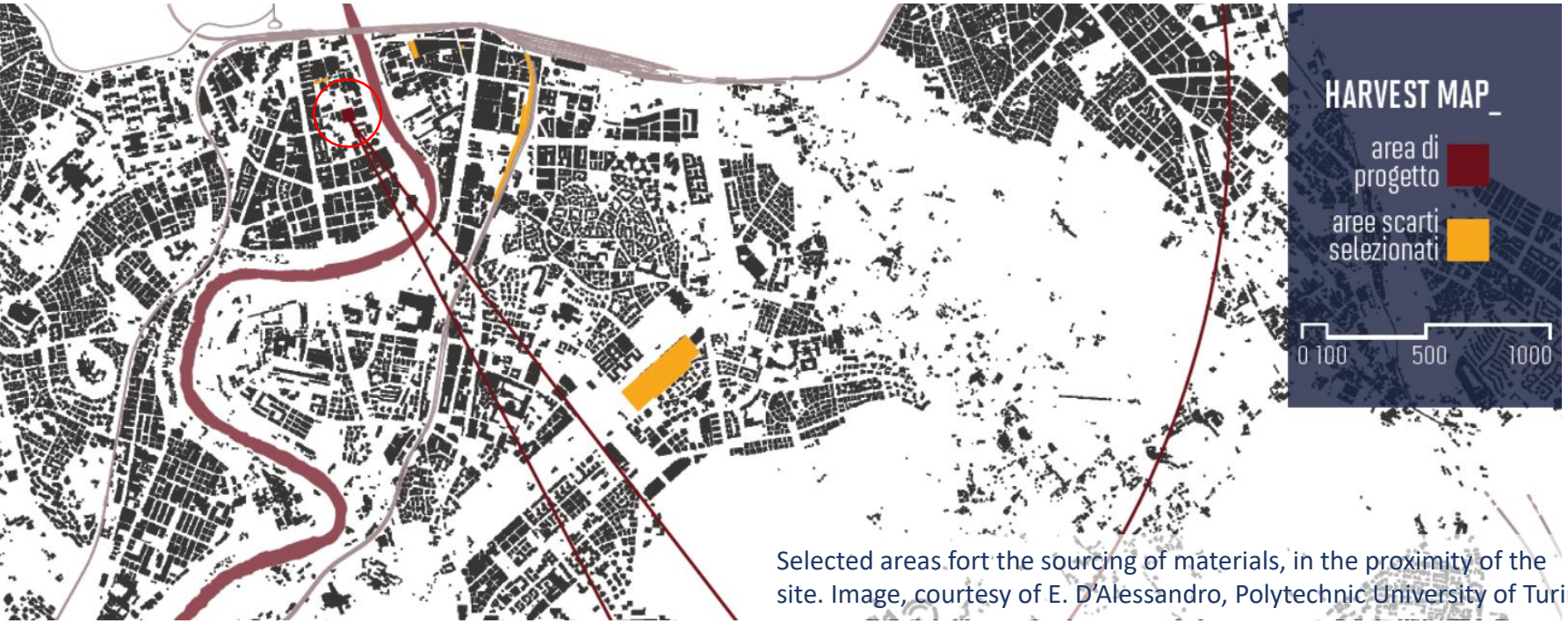


Companies contacted within a radius of 25 km from the project area.
Image, courtesy of E. D'Alessandro, Polytechnic University of Turin.

A harvest map for the urban regeneration of a former industrial site in Rome

Experimentation deals with a landscape of considerable quantities of reusable waste, coming from construction and demolition sites, building residues from collapses, the presence of abandoned infrastructures (1 km of disused railway line) and waste from the commercial supply chain (paper, cardboard, plastic and nylon mix, pallets, textile scraps, bumpers), materials found in the immediate proximity of the site.



Selected areas fort the sourcing of materials, in the proximity of the site. Image, courtesy of E. D'Alessandro, Polytechnic University of Turin.

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A harvest map for the urban regeneration of a former industrial site in Rome

The definition of the *harvest map* was based, in the first phase, on the materials coming from the planned demolition of 2 buildings of the early twentieth century:

- bricks and tiles (whole and fragments, about 160,000 elements), easily separable and reusable
- collapse of the roofs of the Ex Miralanza left in situ tiles in fragments (56,000 Kg) reusable in *cocciopesto* or as inert
- for ferrous and wooden materials, which cannot be recovered due to their state of conservation, a recovery company was contacted with a factory located 13.5 km from the project area: the hypothesis is, in fact, to retain in situ all re-usable materials and to transfer only the waste that cannot be included in the reuse project.

The need to create a new roof, has oriented the research on structures made with metal components, dry and disassemblable:

- two accessible pavilions of the Fiera di Roma complex, abandoned and undergoing demolition, have constituted an important "mine" with steel pillars (54), removable and reassemblable reticular structures, metal tubular uprights for scaffolding (about 9,000) and technical elements, not directly reusable, but to be included in the *harvest map* (PVC window frames)
- research on the recovery cycle of PVC sheets, reusable in the roofing system.

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Conclusions and outlook

- Harvest mapping approach calls for the anticipation of materials selection at the very first stages of design → original architectural outcomes
- Application of upcycling and superuse to the refurbishment of exisisting buildings:
  - gives value to the traditional approach of reuse in restoration in Italy
  - makes maximum value of the energy embodied in the building fabric
  - raises issue of compatibility
- Need for integration/balancing between recycling + upcycling + superuse strategies
- Need to consider the chemical characteristics and the potential of eco and bio toxicity of materials before reusing them → definition of selection criteria (C2C)
- Primary barrier to the superuse approach in Italy: difficulty in interpreting and consequently applying the waste legislation, in particular on *End of Waste* and by-products
- Circular District Tiburtino feasibility study: testing circular potential on a dense, central, evolving neighborhood in Rome, from building stock analysis, to harvest mapping, to the design of a reversible component for the renovation of facades.

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Thank you for your attention

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