Agenzia nazionale per le nuove tecnologie,
l'energia e lo sviluppo economico sostenibile

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The building stock as an urban mine: estimation of the stock of recoverable materials in the regeneration of the built environment

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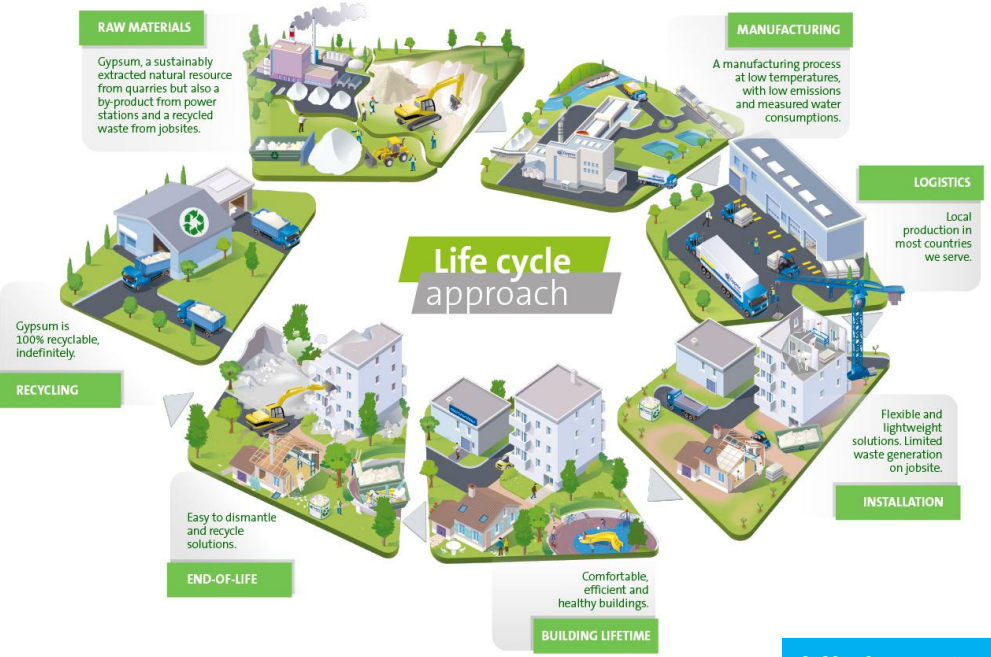
9th International Conference on Sustainable Solid Waste Management
Corfu | 17.06.2022

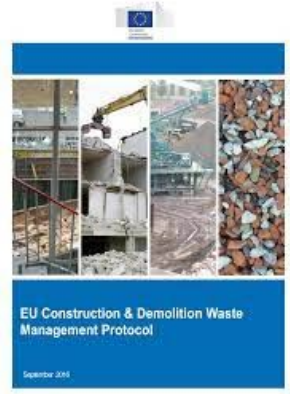
Construction chain and impacts



- ✔ Land and resources depletion:
  - **50% of all extracted materials (almost 2.6 billion tons in Europe and almost 150 million tons in Italy)**
  - **50% of energy consuption**
  - **30% of water consuption**
- ✔ Hudge amont of wastes
  - **30% of all produced wastes in Europe**

High potential for the improvement of resource efficiency and the transition towards the circular economy

EU policies and strategies for resource efficiency and circularity in the construction sector



EU Waste Framework Directive 98/2008

(Art. 11). '**by 2020**, the **preparing for re-use, recycling and other material recovery**, …., of non-hazardous construction and demolition waste ….shall be increased to a **minimum of 70% by weight**'

Construction 2020 strategy | 2012

To be updated in 2021, it aimed at:

- stimulating favorable conditions for investments
- improving the human capital base in the construction sector
- improving **resource efficiency**, **environmental performance** and business opportunities
- strengthen the internal construction market
- promoting the global competitiveness of EU construction companies.

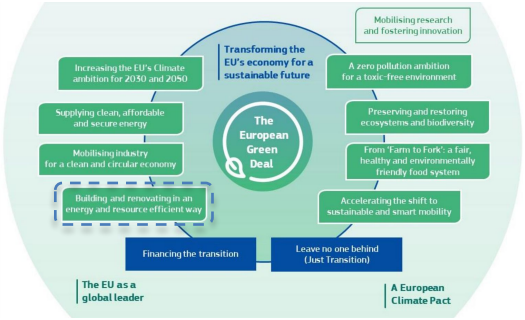
Resource Efficiency Opportunities in the Building Sector | 2014

Defines the steps towards a **better functioning market for recycled construction materials**.

EU Construction and Demolition Waste Protocol | 2016

Aims at increasing confidence in the C&D waste management process and in the quality of relative recycled materials.

EU policies and strategies for resource efficiency and circularity in the construction sector



The European Green Deal | COM/2019/640 final

- States the **important role of the construction sector** within the Green Deal
- Calls for a **renovation wave** for the building sector in 2020
- Foresees a **revision of the construction products regulation** promoting a **design of new and renovated buildings oriented towards the circular use of resources**
- Strictly **links several policies** falling under the umbrella of the EU Green Deal **with the construction sector** and its closely interconnected sectors, such as the **mining quarrying** and the **waste management**.

A new Circular Economy Action Plan For a cleaner and more competitive Europe | COM/2020/98 final

The EU Commission has committed to **launch a comprehensive Strategy for a Sustainable Built Environment in 2021**

The Action Plan **foresees to strengthen the circular use of materials** through:

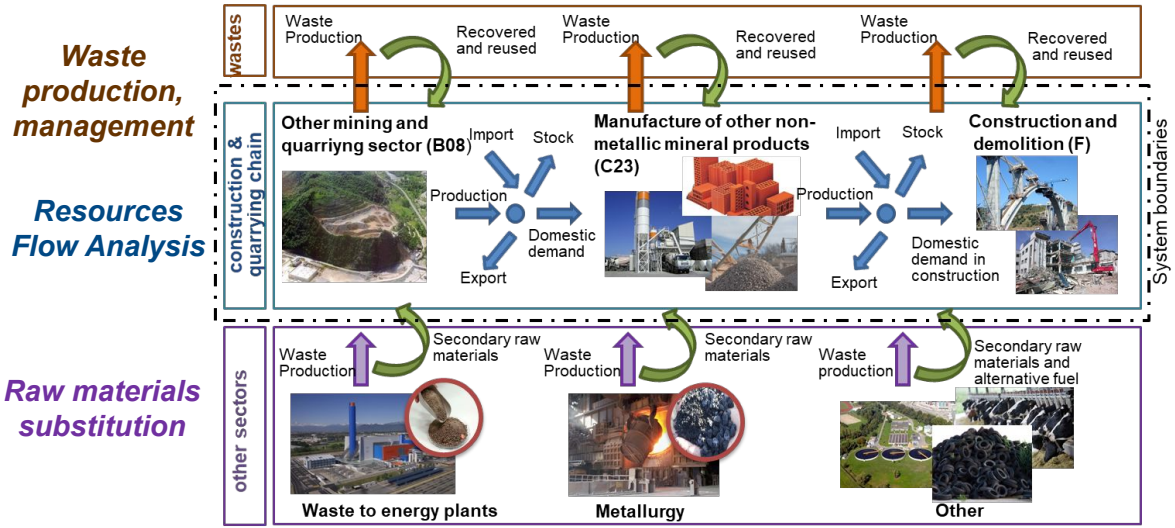
- the improvement of the **durability** and **adaptability** of the built assets
- the integration of **life cycle assessment (LCA)** into public procurements
- the **revision of material recovery targets** with a focus on **insulation materials**
- the safe and circular use of excavated soil to reduce soil sealing.

Toward a resource Efficiency Plan

ENEA – MATTM Agreement

The potential in term of raw material substitution with by-products and recycled wastes is not adequately exploited

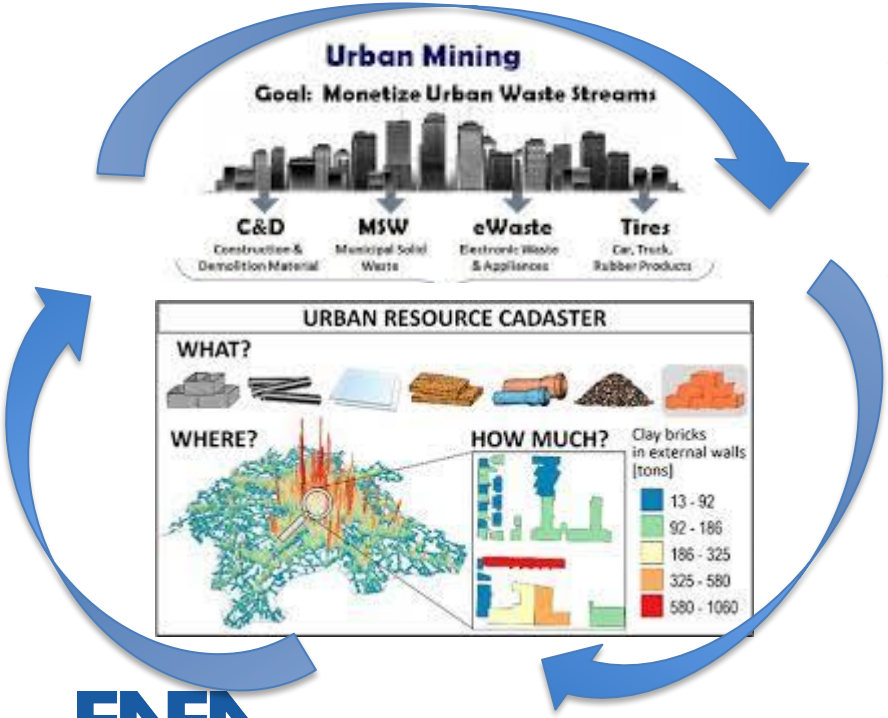
opportunities offered by the circular economy in the construction sector in terms of **waste valorisation and reuse**



Luciano A., Cutaia L., Carletti R., Pentassuglia R., Elmo G., Mancini G.
Resources Optimization and sustainable waste management in construction chain in Italy: toward a resource efficiency plan. Waste and Biomass Valorization (2020) 11:5405–5417 https://doi.org/10.1007/s12649-018-0533-1

Urban mining and Regeneration closing the loops: an integrated management approach

Rethinking at the build environment as an urban mine and then to quantify the built environment stocks and to plan an exploitation of these resources



- Due to technical and socio-economic factors, the stock of materials in the built environment currently only marginally re-enter a closed loop of use
- For the purpose of recirculating the materials, it is necessary to define **which types** of materials are available, their **quantity**, **where** and **when they will be available**, **how and where they can be reused/recycled**, **how much it costs.**

ES-PA Project - "Energy and Sustainability for public administration“ | Circular economy related research task

ENERGIA E SOSTENIBILITÀ PER LA PUBBLICA AMMINISTRAZIONE

_duration: 2017-2023
_budget: 9,6 M€

UNIONE EUROPEA
Fondo Sociale Europeo
Fondo Europeo di Sviluppo Regionale

Agenzia per la Coesione Territoriale

PON GOVERNANCE E CAPACITÀ ISTITUZIONALE 2014-2020

Framework of actions to enhance the skills of the PA in the fields of energetic and ecological transitions

Task A2.3.2

Estimation of the materials that can be recovered in "urban mines" with a specific focus on the build environment

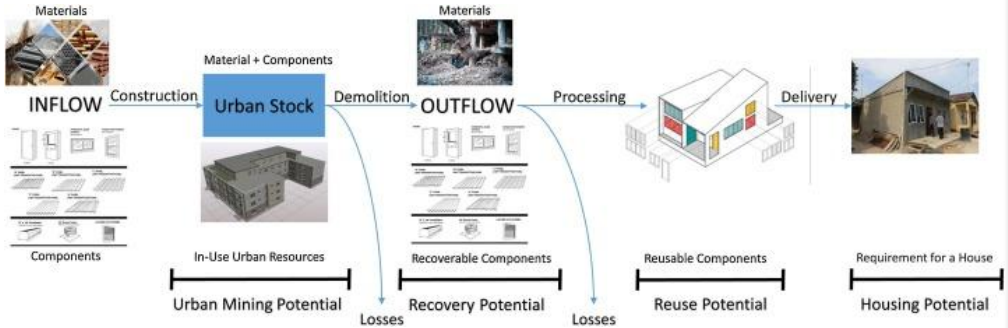
- Expected output: guidelines for businesses and public administrations aimed at estimating the quantities and characteristics of materials that can be used and recovered in urban and industrial areas (urban mining)
- Recipients: national and regional decision makers, officials and technicians
- Implementation: cognitive and **operational tools** will be **outlined for the estimation of residues and stocks present in urban and industrial areas**, **at different scales** (macro/national, intermediate/regional/provincial, local/urban/district/building) - for the implementation of plans and strategies for the recovery of building stocks.
- Collaboration: Research activity developed by Enea in collaboration with «Sapienza» University of Rome, with **circular design experiments** on **3 case studies** in the city of **Rome** (IT), within urban regeneration/re-unctionalisation/renovation projects of existing buildings

ENEA

ES-PA Project – Estimation of the stock of recoverable materials in the built environment and cycle closure: a multi scale toolkit

Multi-scale toolkit

- Identify the materials present in buildings (buildings stocks) in terms of type and quantity.
- define the flows deriving from different intervention scenarios on the buildings (traditional demolition, selective demolition, soft and deep renovation)
- identify the reuse/recovery rate of these materials in different intervention scenarios and available recovery technologies (e.g. valorisation and recovery plants)
- identify the options for reuse and recycling of these materials according to the urban planning (circular design)



MACRO LEVEL (national)	MESO LEVEL (regional or homogeneous construction types)	MICRO LEVEL (municipality, district, single building)
		
National resource efficiency plan	Regional plans or sectorial recovery plans	Urban planning

ES-PA Project – Estimation of the stock of recoverable materials in the built environment: approaches and methodologies

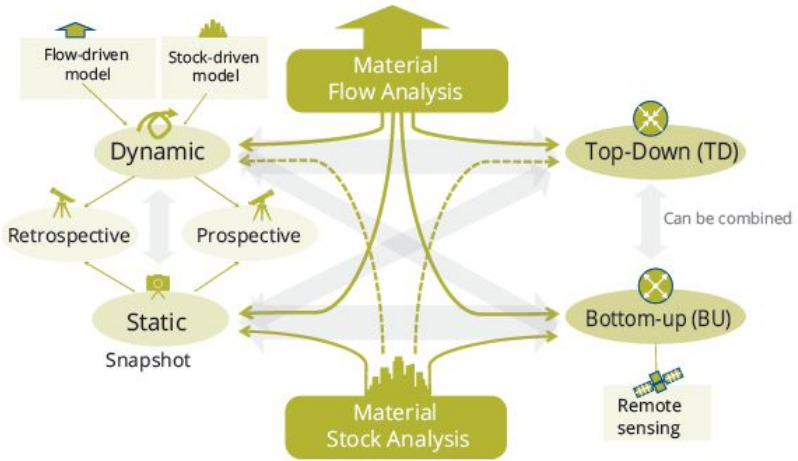
- An increasing number of studies today are analysing – with different approaches - the stock of materials in the urban built environment intending to anticipate and stimulate its circular use and valorisation

Top-down approach

- flow-driven method
- based on macroeconomic or aggregated data
- information on inflows easier to obtain than data on outflows

Bottom-up approach

- driven by information collected from stock inventory
- collection of data relatively detailed and labour-intensive
- allows for greater accuracy in results (composition, intensity and geographic distribution)



ES-PA Project - "Task: Estimation of the stock of recoverable materials in the built environment

ENERGIA E SOSTENIBILITÀ PER LA PUBBLICA AMMINISTRAZIONE

Methodology:
bottom up + top-down approach = **multi-scale toolkit** for different types of public administrations to help estimating and planning the use of secondary materials

Top-down approach based on **statistic data** to the analysis of the national building stock, considering the main building typologies

STEP 1 - Estimation of the national building stock for the main typologies (residential buildings, schools, industrial buildings)	**STEP 2** - Definition of the constructive characteristics of exemplary buildings with commonly found materials and components	**STEP 3** - Estimation of the material stock, aimed at the quantitative and qualitative evaluation of the main materials' availability

Bottom-up/experimental approach on the estimation of materials stock in specific **case studies** and of the potential flows and level of reusability/recyclability in different intervention scenarios

Phase 1: technological analysis of the building **Phase 2:** identification and quantitative estimation of the materials stock in the buildings	**Phase 3:** architectural and environmental redevelopment project of the building with the adoption of circular strategies	**Phase 4:** quantitative estimation of the materials removed and identification of their final destination

Definition of a **toolkit** for public administrations (local/regional/national) to allow a quick estimate of materials stock based on different scenarios of transformation of the building stock

TOOL 1 (macro level) for the estimation of building stock at national level	**TOOL 2** (meso level) for the estimation of building stock at regional level or at level of buildings type)	**TOOL 3** (micro-level) for the estimation of building stock at municipal level/district level/

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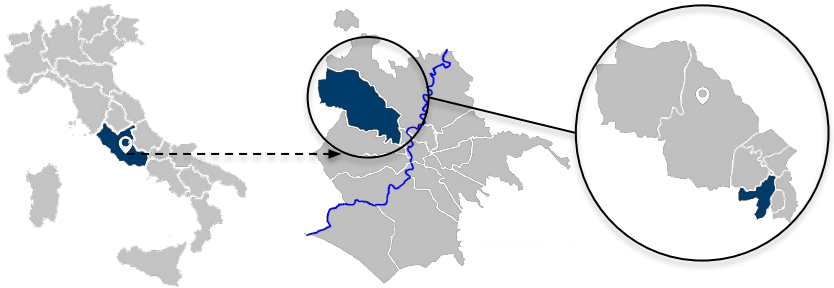
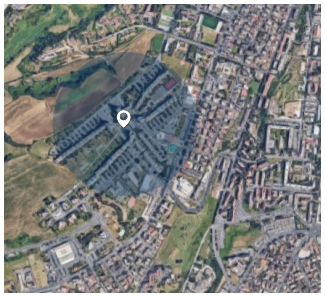
Case study 1: Urban regeneration and refurbishment of the public housing district of Torrevecchia, Rome (IT)

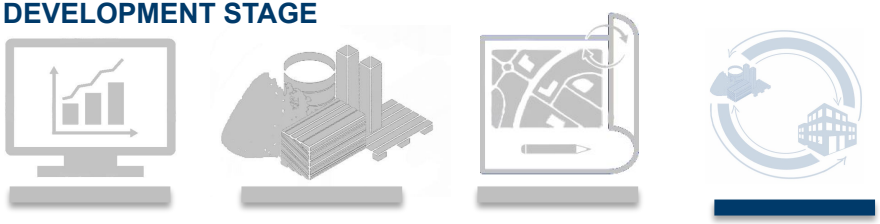




Research activity developed in collaboration with Sara Lucci, student of the Master Degree Course "Architecture-Urban Regeneration", "Sapienza" University of Rome (IT)

- Urban regeneration and environmental retrofit project of the public housing district of Torrevecchia in Rome (1.074 housing units for 3.600 inhabitants)
- *Construction period*: 1978-84
- *Construction system*: pre-fabricated reinforced concrete (coffrage-tunnel)
- *Other prevailing materials*: brick, gypsum board, iron (windows and parapets)

DEVELOPMENT STAGE



Phase 1
Technological analysis of the building

Phase 2
identification and quantitative estimation of stock materials

Phase 3
architectural and environmental redevelopment project of the building with the adoption of circular strategies

Phase 4
quantitative estimate of the materials removed and identification of the final destination

- The district contains recurring building types largely widespread in Italy with the same construction type and same materials

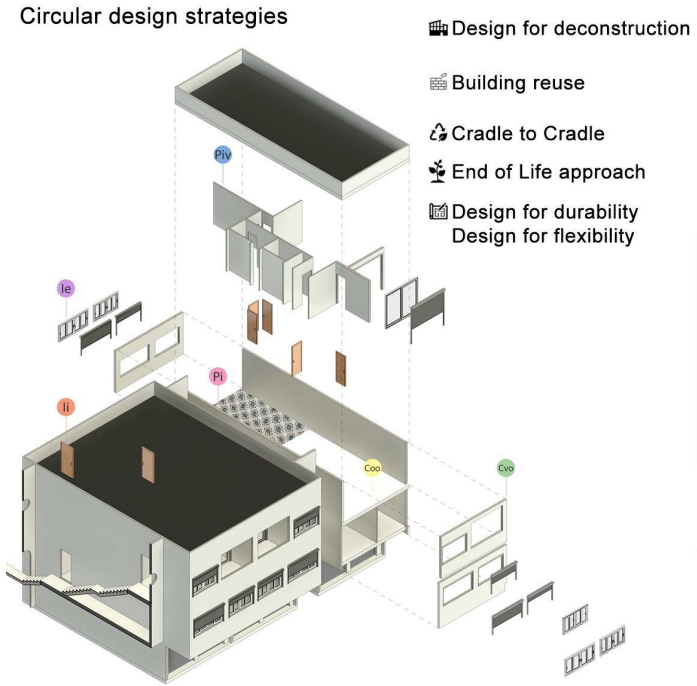
Case study 1: Urban regeneration and refurbishment of the public housing district of Torrevecchia, Rome (IT)

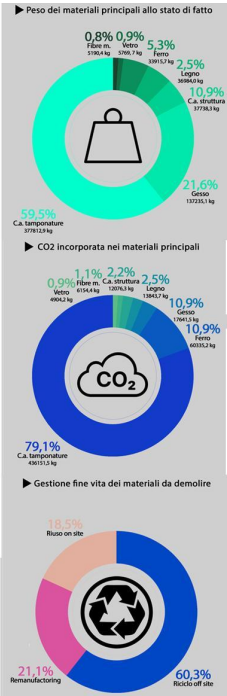
Phase 2 - inventory of the materials stock, making use of 3 indicators: volume, weight and embodied carbon
The stock analysis has identified reinforced concrete as the prevailing material in weight

Phase 3-4 - estimation of the amount and typologies of materials destined to be demolished in a renovation scenario, with solutions for their full recovery (18,5% on-site reuse, 60,3% off-site recycling, 21,1% remanufacturing).

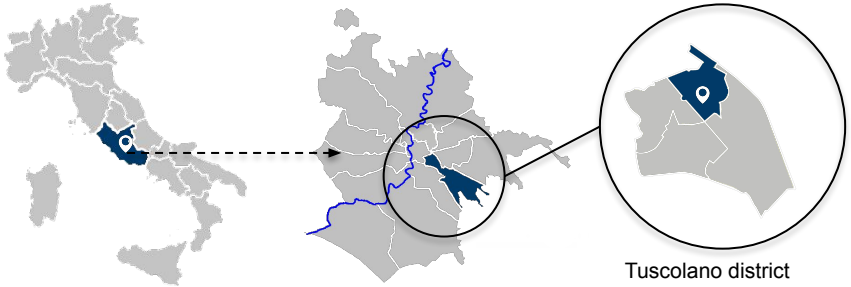
Demolitions and estimate of volume/weight/embodied CO2 in existing materials

Circular design strategies





Case study 2: Re-functionalisation of the former public transport buses garage in Ragusa Square, Rome (IT)



Research activity developed in collaboration with Martina Avena, student of the Master Degree Course "Architecture-Urban Regeneration", "Sapienza" University of Rome (IT)

- Urban regeneration and re-functionalisation project of the disused ATAC (public transport buses) garage area in Piazza Ragusa in Rome (11.000 sqm)
- *Construction period*: 1928-1940 / 1953-1955
- *Construction system*: frame structure in reinforced concrete with thin vaulted roof
- *Other prevailing materials*: iron, bricks, plaster, wood, glass

DEVELOPMENT STAGE

Phase 1
Technological analysis of the building

Phase 2
identification and quantitative estimation of stock materials

Phase 3
architectural and environmental redevelopment project of the building with the adoption of circular strategies

Phase 4
quantitative estimate of the materials removed and identification of the final destination

- Construction types rather widespread in Italy

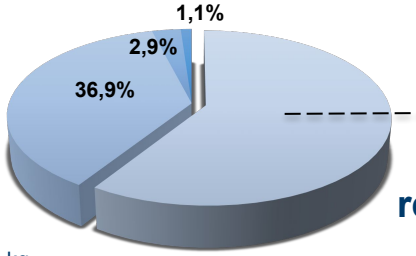
Case study 2: Re-functionalisation of the former public transport buses garage in Ragusa Square, Rome (IT)

Weight:

1,1% plaster
522.824 kg

2,9% bricks
682,830 kg

36,9% iron
18.328.098 kg



59,1% reinforced concrete
29.312.232 kg

incidence 0%
wood and glass
11.245 kg + 9,890 kg

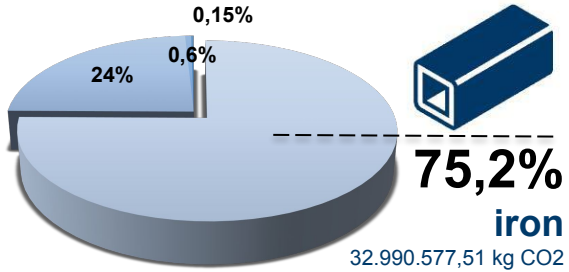
Embodied carbon:

0,1% wood
20.242,71 kg CO2

0,6% bricks
259.475,73 kg CO2

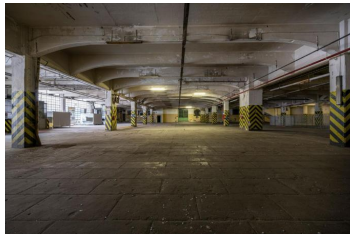
0,15% plaster
67.967,19 kg CO2/

24% Reinforced concrete
10.552.403,52 kg CO2

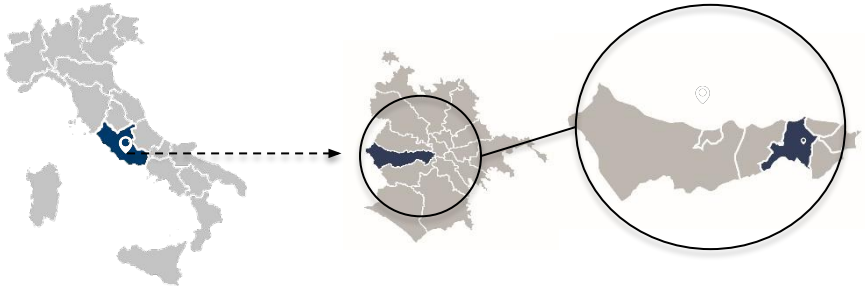


75,2% iron
32.990.577,51 kg CO2

incidence 0%
glass
8.406,67 kg CO2



Case study 3: Renovation of the «ITIS Alessandro Volta» school building in Bravetta street, Rome (IT)

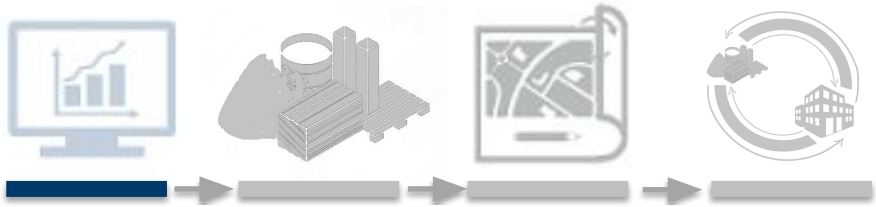


Italy, Lazio Region | Rome, Municipio 12 | Buon Pastore district

Research activity developed in collaboration with Gaetana Katia Bruno, student of the Master Degree Course "Architecture-Urban Regeneration", "Sapienza" University of Rome (IT)

- Urban regeneration and renovation project of the Industrial Technical Institute “Alessandro Volta” in Bravetta 351 street, Rome (IT)
- *Construction period*: 1963-1964, 1971-1972,1982
- *Construction system*: suspended steel structure
- *Other prevailing materials*: concrete, fiber cement, glass

DEVELOPMENT STAGE



Phase 1
Technological analysis of the building

Phase 2
identification and quantitative estimation of materials stock

Phase 3
architectural and environmental redevelopment project of the building with the adoption of circular strategies

Phase 4
quantitative estimate of the materials removed and of their final destination

Case study 3: Renovation of the «ITIS Alessandro Volta» school building in Bravetta street, Rome (IT)

Criticalities in the materials stock, typical of the school buildings of the same age, that need to be solved to improve the level of recyclability

_Presence of asbestos

1 In the fiber cement **PERIMETER FLAPS**

2 In the vinyl-asbestos used as a finish for the laboratories and/or classrooms **FLOORING** of 2 floors of the building

3 In the **TOP COVER** but in a good state of conservation both internally and externally

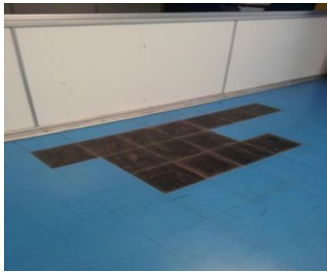
_Carbonation of concrete

1 In the **PERIMETER BUFFERS** (breakdown of the masonry and oxidation of the reinforcement concrete covers exposed to the action of atmospheric agents)

_Water infiltration and humidity

1 In the **FLOORS** (in predalles and covered with riverclack slabs)

2 In the suspended ceiling PANELS



Conclusions

- The combined top down and bottom up approach allows you to operate at different scales in order to give different solutions for different recipients (national governments for the development o national plans and strategy, local authorities for sectorial and urban planning)

- The results of the bottom up approaches activity provide useful inputs for the standardization of main building typologies in terms of recoverable stocks and reuse/recycling options

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