Materials
Sistems
Building Envelope
Processes
Industry
Skills
Know-how
Project
Renovation
Construction
Environmental Sustainability
Structural safety
Energy Efficiency
R&D
Technology Transfer
Construction sector
Buildings
Smart City
Mobility
Renewable
Urban Regeneration

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ENEA CNR

Reuse and Recycling of secondary raw materials and wastes in Buildings: case studies in Italy

OERCO2 | International Seminar - Seville

May 16th 2018

Luca Laghi | Technical Director - CertiMaC

Materials | Energy | Innovation

CERTIMAC at a Glance…

CertiMaC at a glance

FOUNDED AND HELD BY ENEA E CNR	NOTIFIED BODY N.2685 CPR (EU) 305/2011	NO-PROFIT INSTITUTE OF RESEARCH
The main actors of scientific research in Italy– 28,5% share for each member	For the construction products classified with VVCP 3 on more than 20 harmonised standard	According to European Commission Comunication (2006/C 323/01)

IN THE HEART OF INNOVATION ON MATERIALS

ecosystem in which strategic resources for the development of Industry, Research and Innovation on materials are concentrated

STRATEGIC PARTNERSHIP WITH INDUSTRY

+300 customers +5000 tested materials to develop high-performance products and solutions

NETWORKING & PROJECTS

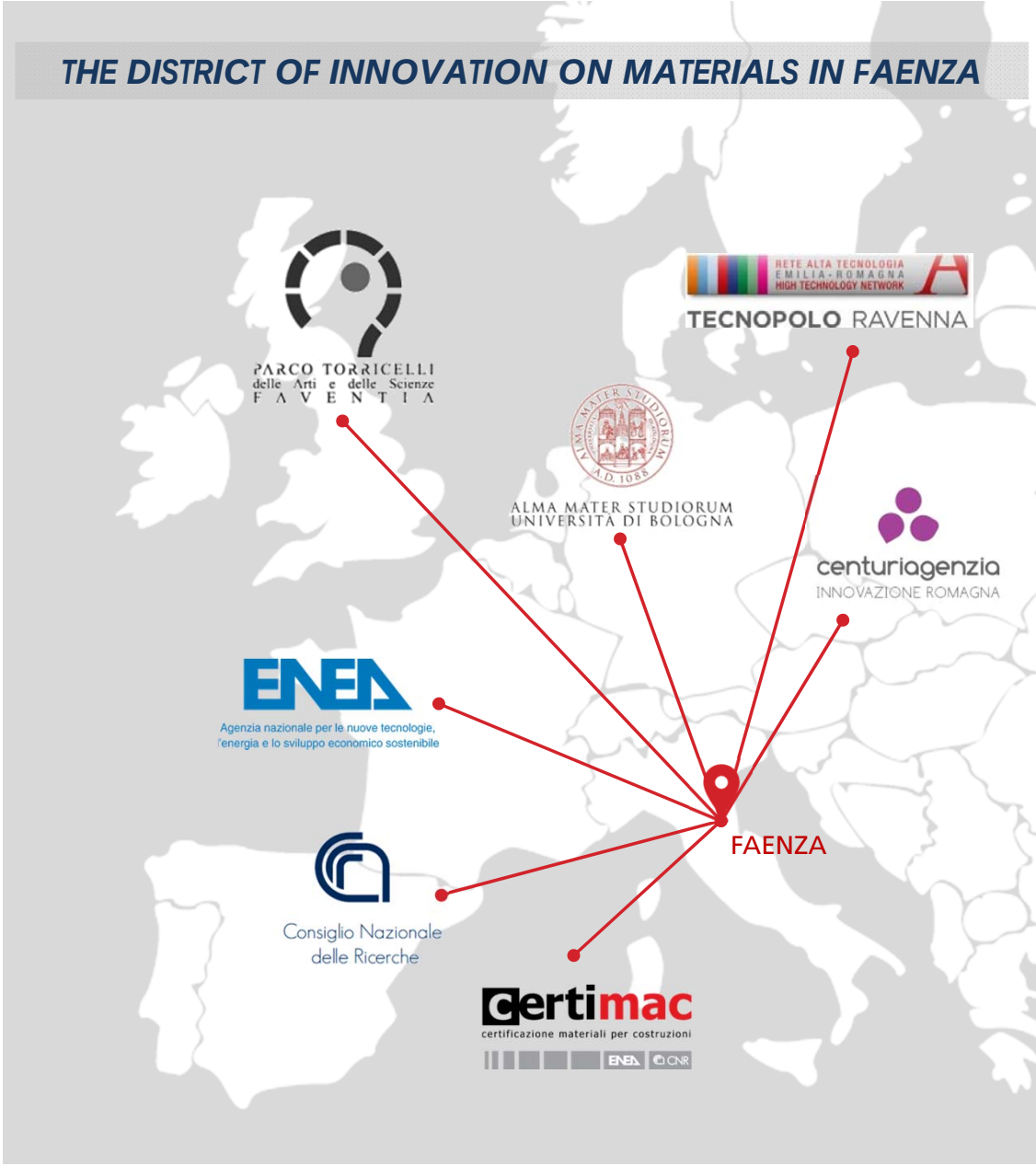
editing and coordination of funded pluriannual research projects: HORIZON 2020, INTER-REG, ERASMUS +, POR FESR EMILIA-ROMAGNA, …

FLEXIBLE AND DINAMIC ORGANIZATION

team of engineers, chemists, energy and material specialists, Services with high innovation content to tests, analysis, product certifications and technical consulting

Know-how. Solutions. Results. This is our mission.

THE DISTRICT OF INNOVATION ON MATERIALS IN FAENZA



International network of Innovation

CertiMaC bewares always to Europe and global innovation processes:

- As an active research organization in several ad-hoc groups of **European Technical Committees** and **Working Groups**, CertiMaC plays an active role at international level in the processes of pre-normative research, development and validation of different experimental methods for a wide range of materials testing to support the **CEN** activities, in order to define the **reference standard at EU level.**
- Several **collaborations with international network** of Research Center and Universities, thanks to the participation as a member of the European Platform **ECTP – European Construction Technology Platform**.
- CertiMaC is leading several **pluriannual research projects funding by European Commission** that allowed to consolidate the relantionship with Accademy, Technological Centers and European Laboratories.
- Active collaborations also outside Europe, thanks to several interactions with partner from **Mid-East area** and **Research Center in USA.**

Agenda

01 **Wastes use and Recycling in Buildings**

02 Application 1 | Masonry Elements

03 Application 2 | Flooring systems

04 Application 3 | Mortars & Screeds

Wastes and Recycling at a Glance…

According to the waste management hierarchy, **landfilling is the least preferable option and should be limited to the necessary minimum**.

The **Directive 1999/31/EC** has the purpose **to prevent or reduce as far as possible negative effects on the environment, in particular on surface water, groundwater, soil, air, and on human health from the landfilling of waste by introducing stringent technical requirements for waste and landfills.**

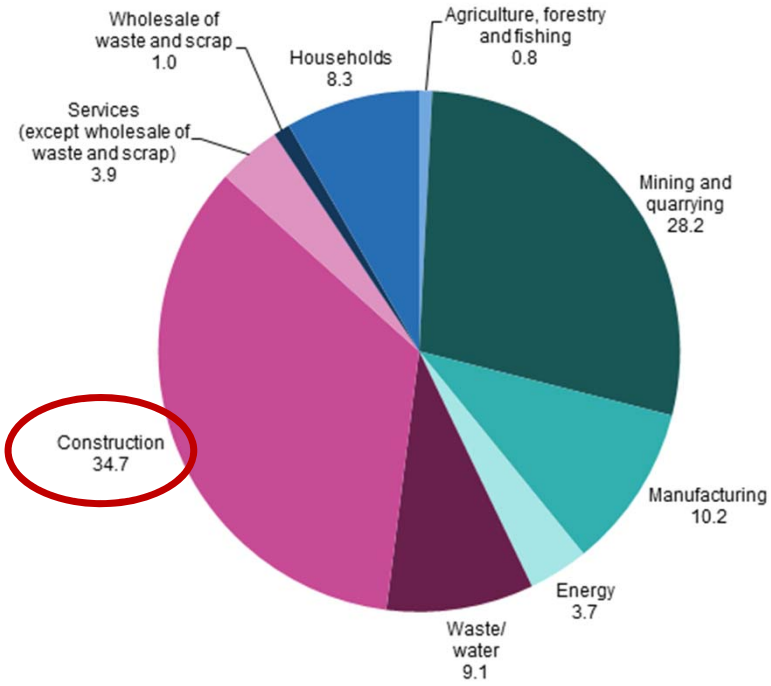
The Landfill Directive defines the different categories of waste (municipal, hazardous, non-hazardous and inert wastes) and applies to all landfills, defined as waste disposal sites.

Source: European Commission

At a Glance...

	Total		Mining and quarrying	Manufacturing	Energy	Construction and demolition	Other economic activities	Households
	(million tonnes)	(kg per inhabitant)			(%)			
EU-28	2 502.9	4 931	28.1	10.2	3.7	34.7	14.9	8.3
Belgium	65.6	5 838	0.1	21.7	2.1	40.2	27.3	8.6
Bulgaria (1)	179.7	24 872	88.6	:	5.1	0.7	4.0	1.5
Czech Republic	23.4	2 223	1.0	18.8	4.3	40.2	21.8	13.9
Denmark	20.1	3 558	0.1	6.4	5.4	52.6	18.5	17.1
Germany	387.5	4 785	1.9	15.8	2.6	53.3	16.9	9.5
Estonia	21.8	16 587	36.3	20.2	32.6	3.1	5.6	2.2
Ireland (1)	15.2	3 285	17.8	:	2.1	12.4	57.6	10.0
Greece	69.8	6 404	67.9	7.0	15.6	0.7	2.3	6.5
Spain	110.5	2 378	16.9	13.4	4.8	18.5	28.3	18.3
France	324.5	4 913	0.7	6.7	0.5	70.2	13.1	8.8
Croatia (1)	3.7	879	0.1	:	3.2	16.6	48.9	31.2
Italy	159.1	2 617	0.6	16.7	2.0	32.5	29.5	18.6
Cyprus (2)	2.1	2 406	:	:	:	31.0	48.9	20.2
Latvia	2.6	1 315	0.2	9.4	27.8	17.3	18.3	27.1
Lithuania	6.2	2 114	0.4	42.1	1.6	7.0	30.1	18.7
Luxembourg	7.1	12 713	1.8	4.0	0.0	84.5	6.1	3.4
Hungary	16.7	1 688	0.5	16.2	13.9	20.7	31.0	17.7
Malta (1)	1.7	3 896	2.2	:	0.2	74.5	13.8	9.3
Netherlands	133.2	7 901	0.1	10.1	1.3	68.1	14.1	6.4
Austria	55.9	6 541	0.1	9.7	0.9	72.1	9.8	7.5
Poland	179.0	4 710	42.3	17.6	12.2	9.5	13.7	4.6
Portugal	14.6	1 402	1.9	17.9	1.2	10.3	36.3	32.3
Romania (1)	175.6	8 820	87.0	:	4.0	0.6	6.2	2.2
Slovenia	4.7	2 273	0.2	28.1	13.5	17.4	28.9	12.0
Slovakia (1)	8.9	1 636	3.2	:	6.1	15.6	55.4	19.6
Finland	96.0	17 572	65.4	10.7	1.5	17.0	3.7	1.7
Sweden	167.0	17 226	83.2	3.4	1.1	5.3	4.5	2.5
United Kingdom	251.0	3 885	10.5	3.2	1.3	48.0	26.0	11.0
Iceland (3)	4.5	1 651	0.0	17.6	0.3	2.1	36.1	44.0
Liechtenstein	0.6	14 919	1.7	2.0	0.1	0.0	0.4	95.9
Norway (1)	11.7	2 283	2.8	:	1.3	23.0	52.7	20.3
Montenegro	1.2	1 872	22.5	5.2	31.7	9.2	15.3	16.1
Former Yugoslav Republic of Macedonia	2.2	1 058	3.4	67.9	23.3	0.5	4.9	0.0
Serbia	49.1	6 890	84.5	1.8	9.1	0.6	0.7	3.3
Turkey (4)	73.1	947	4.2	:	32.8	:	20.2	42.8
Bosnia and Herzegovina	0.5	1 161	1.6	27.2	71.1	0.0	0.0	0.0
Kosovo (UNSCR 1244)	1.0	574	19.3	7.0	0.0	0.3	26.3	47.0

(1) Other economic activities includes also manufacturing.



Source: Eurostat
Waste generation by economic activities and households - 2014

The Answer…

Sustainability in construction starts as a **«strategic junction» between the «beginning»** and the **«end of life».** In other words, **where materials become wastes,** a sustainable approach allow us to consider them as **«secondary raw materials»…**

To do that…

Knowledge Triangle

CertiMaC is located there…

Laboratory point of view

Waste as potential answer to a need

Any kind of solid or semi-solid material (within certain boundaries of liquid phase) originating from productive processes can **potentially** integrated into an industrial product/process that constitute the starting material in order to:

- **Complete/improve the mix design**
- **increase specified properties or reduce secondary undesiderable effects**
- **lighten or strenghten finished products**
- **reduce the environmental and economic cost of the «wastes management»**

Growing need in the construction field for high-performance building envelope components

Increasing attention for environmental sustainability of employed materials

Increasing interest in Mediterranean countries for transpirant and high-thermal mass materials such as bricks

(good insulation + passive solution for reducing cooling energy demand)

Choosing and using a waste for a "second life"

It is close to impossible to define the **ideal waste** and to aprioristically define its **employability** in absolute terms…

Six main elements contribute to the overall complexity of the issue:

- ✓ Chemical composition of waste
- ✓ Broad compositional spectrum along the productive year
- ✓ Different effects of the same waste added to different formulas/mix design with diverse and heterogeneous chemical-physical composition
- ✓ Conditions for waste employability (granulometry, moisture, maximum amount, as slurry or in particles…)
- ✓ Classification of waste and disposal conditions (EWC code)
- ✓ Availability of waste (volume produced/time)

From waste to secondary raw materials

Aims sought:

- ✓ **Economic Cost reduction due to «waste management»**
- ✓ **Properties optimization**
- ✓ **Reduction of the environmental impact**

Not waste products, but **secondary raw materials**, as they constitute a strategic opportunity for a cost-effective improvement of manufactured products toward a real **«Industrial Symbiosis».**

Essential requirements

Availability
- continuous throghout the whole year
- low-cost
- near to the production site

Compatibility
- with the process
- with the product (mix design, etc.)

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Application 1 | Innovative Masonry Elements

Energy efficient Masonry Blocks

Lightweight cementitious mix produced with:

- ✓ **Expanded** Perlite
- ✓ **Blast Slag Fournace** (reactive effect as binder) and **Fly Ashes** reducing cement content of about **50%**.

optimising and engineering:

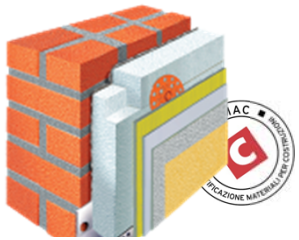
- ✓ Mechanical and Thermo-Hygrometric properties.
- ✓ Layout and Geometry toward the nZEB Standard (in terms of Thermal Transmittance value).

Raw Materials

Mix Design | $\lambda_{10,mat}$

Unit | $\lambda_{10,unit}$

Masonry System | R



↓ Cement

Expanded Perlite

REDUCTION

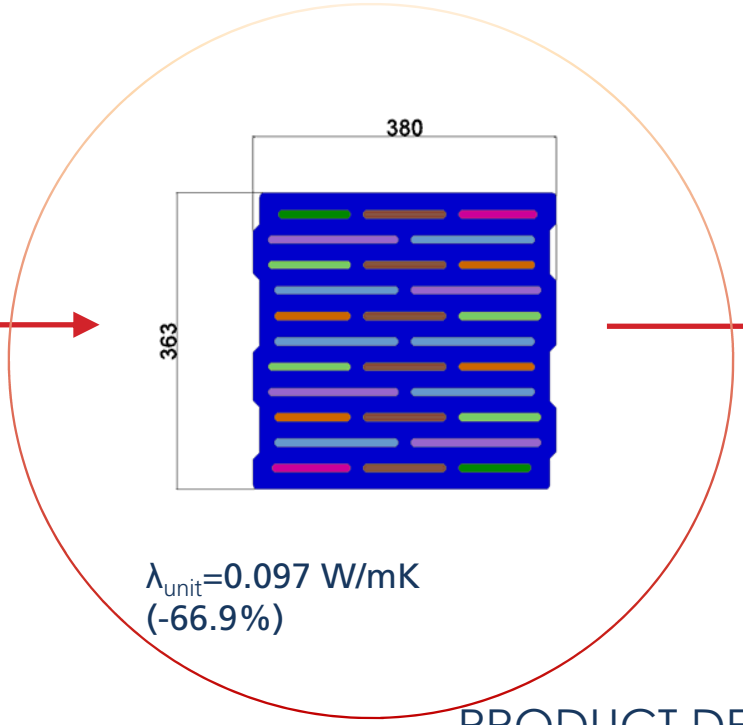
+

Blast Slag Furnace

Fly Ash

SECONDARY RAW MATERIALS ADDITION

λ_{mat}=0.12 W/mK
(-50%)



λ_{unit}=0.097 W/mK
(-66.9%)

PRODUCT DEVELOPMENT & CHARACTERISATION through FE Modeling and Experimental Campaign

Layout Engineering towards
U_{mas}=0,24 W/m²K

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Application 2 | Innovative Continous Flooring System

Continuous Ceramic

An innovative way of using ceramic waste to obtain uniform and monolithic appereance

Produced with **80% recycled ceramic** and **20% of binder** (bi-component acqueous solution) + anti-bacterial compound.

- ✓ It adapts to any shape and dimension
- ✓ Cost-effective installation with no production of scraps.
- ✓ Allows casting with reduced thickness.

Recycled pre and post-consumer ceramic

Cold processing minimises energy consumption

Zero VOC emissions

No scraps from production and installation

Radiant heating systems

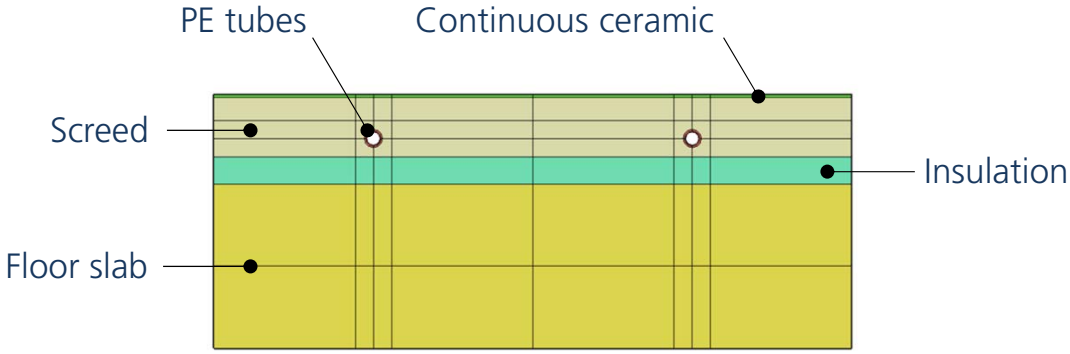
It can be employed with reduced thicknesses (≈ 1-2 mm)
Compared to traditional ceramic tiles or other materials it allows to increase the heat exchange towards the indoor environment.

Very good thermal conductivity value **0.1 – 0.3 W/mK**

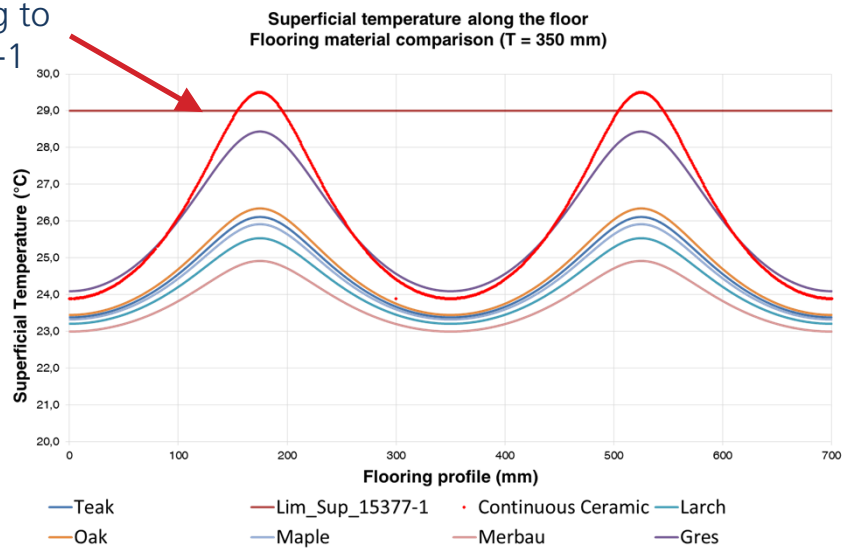
(e.g. traditional fine porcelain stoneware is around 1 W/mK)

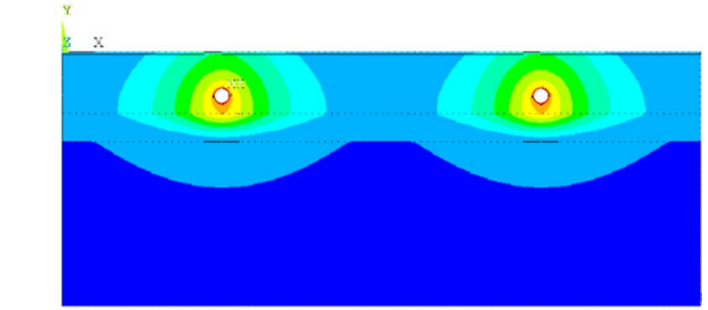
Outstanding adhesion properties **4.42 N/mm²**

(the minimum limit for the best category is ≥1 N/mm²)



Limit according to UNI EN 15377-1





Temperature profile

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Application 3 | Innovative Mortars & Screeds

Sustainable Mortars/Plasters and Screeds

An innovative way to develop innovative and sustainable materials replacing aggregate and «traditional cement» with secondary raw materials through the following steps:

1. Chemical and Physical analysis of wastes - **Assessment on Waste**
2. Mix design with secondary raw materials (as aggregates and binder) – **Feasibility Study**
3. Experimental characterisation according to EU Standards to investigate performances and undesirable phenomena – **Experimental Validation and Product/Component Engineering**

Sustainable Mortars/Plasters and Screeds

Case Study A

Aggregate replaced by:

- ✓ **PPR (Porcelain Polishing Residue)** – 50% w/w
- ✓ **Ground Clam Shells** – 50% w/w

Binder replaced by:

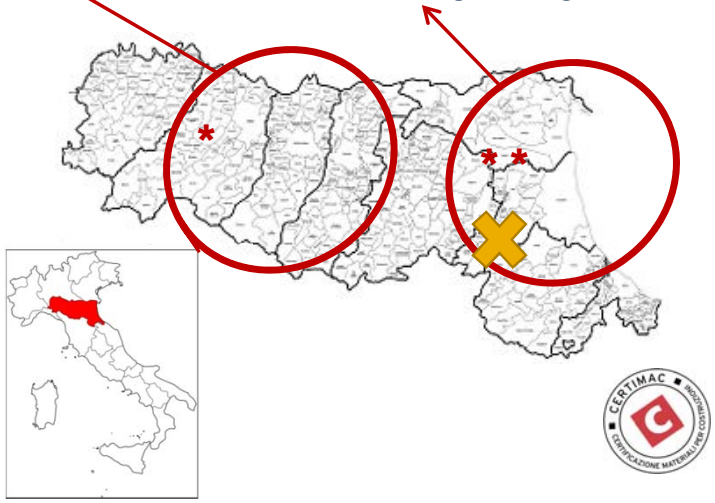
- ✓ **PPR (Porcelain Polishing Residue)** – 30% w/w due to the Pozzolanic effect supporting the mechanical strength of the material

Additives:

- ✓ Air entraining agent to foster the lightening and the insulation degree of the materials developed

PPR Sample «as is»

Clam Shell after calcination and before grinding



* *The largest industrial district in the world for porcelain stoneware production*

* * *Regional Maritime District devoted to Mussel Breeding*

Sustainable Mortars/Plasters and Screeds

Case Study B

Aggregate replaced by:

- ✓ **PPR (Porcelain Polishing Residue)** – 50% w/w
- ✓ **Ground Tires** (with three different granulometries – 50% w/w)

Binder replaced by:

- ✓ **PPR (Porcelain Polishing Residue)** – 30% w/w due to the Pozzolanic effect supporting the mechanical strength of the material

Additives:

- ✓ Air entraining agent to foster the lightening and the insulation degree of the materials developed

PPR Sample «as is»

0,5 mm - 1 mm

1 mm - 2,5 mm

2 mm - 4 mm

Tires ground

Conclusion

- ✓ **Landfilling** is an even more critic issue to be managed
- ✓ **Building industry, through green policies and green marketing,** requires even more sustainable and cost-effective solutions to foster the same (or higher) performances in a more sustainable way

Industrial Symbiosis is one of the answer toward a more sustainable use of Natural Resources…

WELCOME TO THE DISTRICT OF INNOVATION ON MATERIALS

CertiMaC arises in the Tecnopole of Faenza
in the heart of the district of Research and Technological Transfer on Materials

We are waiting for you!

| SHARE WITH US|

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