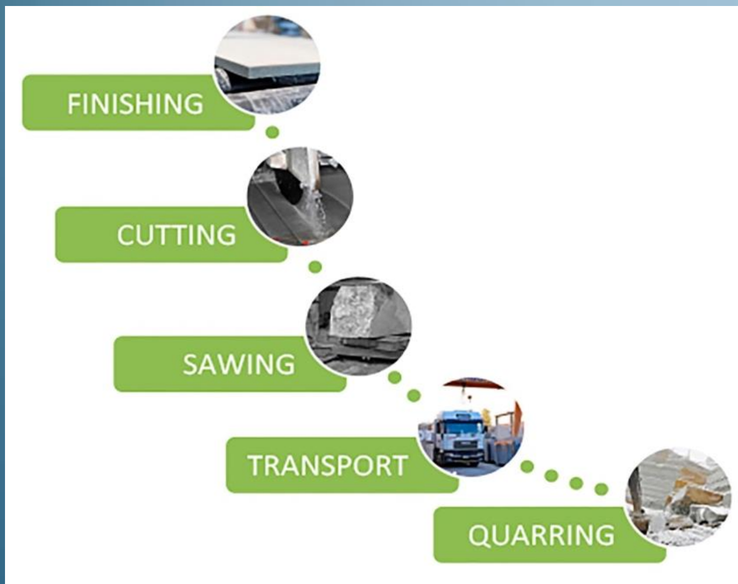
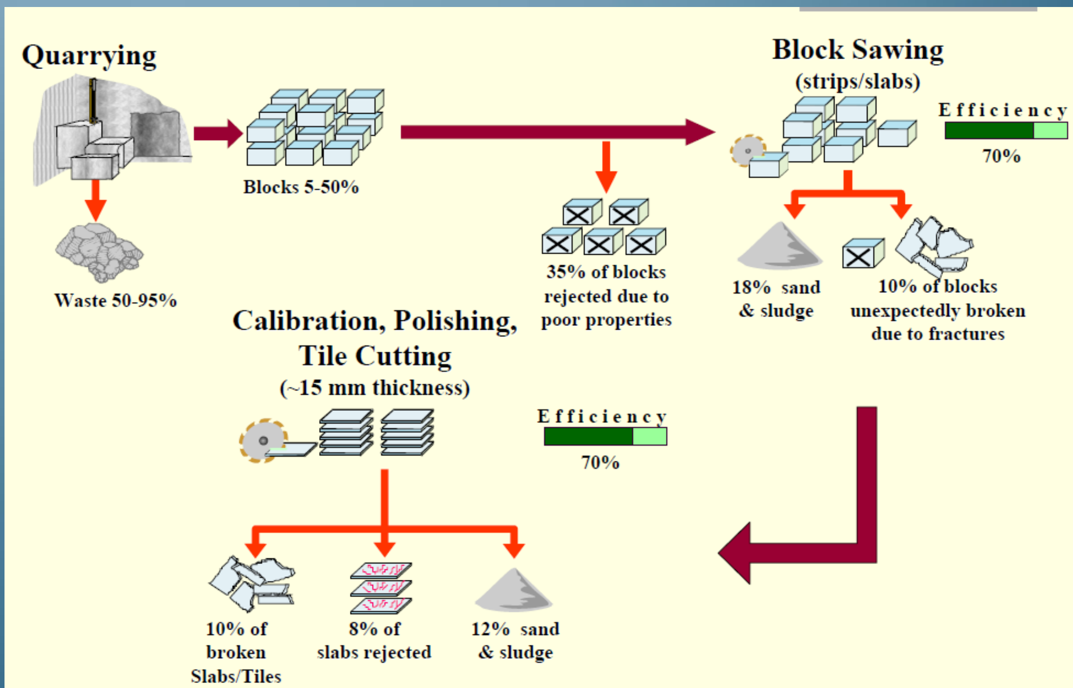
Recycling of Natural Stones slurries: an analysis through the environmental and economic indicators

Cristina Rabozzi – Environmental Consultant, Italy

STONE PRODUCTION CHAIN





STONE WASTES ARE GENERATED IN HUGE QUANTITIES

- Quarrying activities: 50% to 95%

- Processing activities: 30% to 40 %

Quarrying wastes

- Defective or “third choice” blocks
- Large irregular blocks (≥0.2 m3)
- Small irregular blocks (dimension < 0.5 m)
- Small particles (splints, chips), and fine size
- sand and slurry

Processing wastes

- Large to medium size broken pieces called scrap
- Medium to small size pieces like splints, flakes, chips
- Fine size particles mainly in the form of slurry

STONE WASTE MANAGEMENT

Through implementation of a proactive waste management strategy environmental degradation can be avoided.

This is achieved through:

1. the modification of productive processes to adopt cleaner technologies
2. the reuse of waste materials

Additionally, an opportunity exists for companies to distinguish themselves as a socially responsible and environmentally considerate operation.

KEY PERFORMANCE INDICATORS 1/4

Key Performance Indicators are a set of quantifiable measures, agreed to beforehand, that a company or industry uses to gauge or compare performance in terms of meeting their strategic and operational goals.

KPI 1 - Production Rate

Production rate is the number of goods that can be produced during a given period of time. Alternatively, the amount of time it takes to produce one unit of a good.

KPI 2 - Yield

Yield is the quotient of the saleable or useful product to the quantity of extracted material.

KEY PERFORMANCE INDICATORS 2/4

KPI 3 - Stripping ratio
The main characteristic employed in economic evaluation of open pit mining is the Stripping ratio (SR) Stripping ratio is the volume of removed waste-overburden per unit of mineral.

KPI 4 - Operational availability
Operational availability is a measure of the average availability over a period of time and it includes all experienced sources of downtime, such as administrative downtime, logistic downtime, etc.

KPI 5 - Equipment Utilisation
Equipment Utilization is defined as the percentage of plant operating time during which equipment is in production, that is, production is not prevented by equipment malfunction, operating delays, or scheduled downtimes.

KEY PERFORMANCE INDICATORS 3/4

KPI 6 - CO_2 and Other Emissions

One of the most commonly used indicators in order to monitor energy efficiency is the Specific CO2 which is the kg of CO2 emitted for the production of 1 t of product (*CO2-e occurring during blasting / Direct emissions from Combustion sources / Indirect CO2 emissions, equivalent for every Kwh of electricity consumed)*

KPI 7 - Energy Consumption and Resource Management

This indicator is very important to evaluate the energy efficiency of the process :
Direct energy consumption by primary energy source/ Electricity purchased/Specific heat consumption/ Alternative fuels)
Transport constraints (average distance that can be covered from source to customers)

KPI 8 - Natural Resources

Biodiversity: Quarries with a rehabilitation plan in place/ Quarries screened for international biodiversity Sensitivity/ Quarries with red listed species
(from IUCN protected species list)/ Quarries which operate within or adjacent to an internationally protected area, etc.)

KEY PERFORMANCE INDICATORS 4/4

KPI 9 - Materials
Quantity of quarried material / Alternative raw materials rate/ Consumption of material

KPI 10 - Waste
Dust disposed on-site/ Non hazardous waste recovered/ Non hazardous waste disposed / Hazardous waste recovered / Hazardous waste disposed

KPI 11 - Natural Resources
Biodiversity: Quarries with a rehabilitation plan in place/ Quarries screened for international biodiversity Sensitivity/ Quarries with red listed species (from IUCN protected species list)/ Quarries which operate within or adjacent to an internationally protected area, etc.)

KPI 12 - Water
Production in regions with (extreme) water scarcity/ Total water withdrawal from ground water/open water/municipal supplier/ Quantity of water consumed/ Sites equipped with a water recycling system

APPLICATION OF SUSTAINABLE INDICATORS

The goal of sustainable development is to promote economic activity with environmental integrity, social concerns and effective policy strategies

- Assessment before selecting a recovery option should be carried out
- The assessment of the performance of a waste recovery option is sensitive due to the variety of factors that affect it

- Indicators can be established to assess sustainability

The established Sustainable Development Indicators (SDIs) are divided in 3 categories:

- Environmental (i.e. energy, transport, etc.)
- Economic (i.e. cost, added value, etc.)
- Social (i.e. new jobs created)

SUSTAINABLE DEVELOPMENT INDICATORS (SDIs)

Environmental indicators:

- Specific volume of stone waste managed
- Indicative water consumption during treatment per unit of stone waste
- Energy consumption
- Chemicals/Reagents consumption and use of dangerous substances (reagents, chemicals)
- Transport constraints (average distance that can be covered from source to customers)
- Environmental incidents (reportable)

Economic indicators:

- Overall indicative treatment and handling costs
- Indicative capital costs of waste management facilities (if applicable)
- Indicative savings from landfill fees and rehabilitation costs
- Total R&D expenditure/turnover
- Profit making/Added value

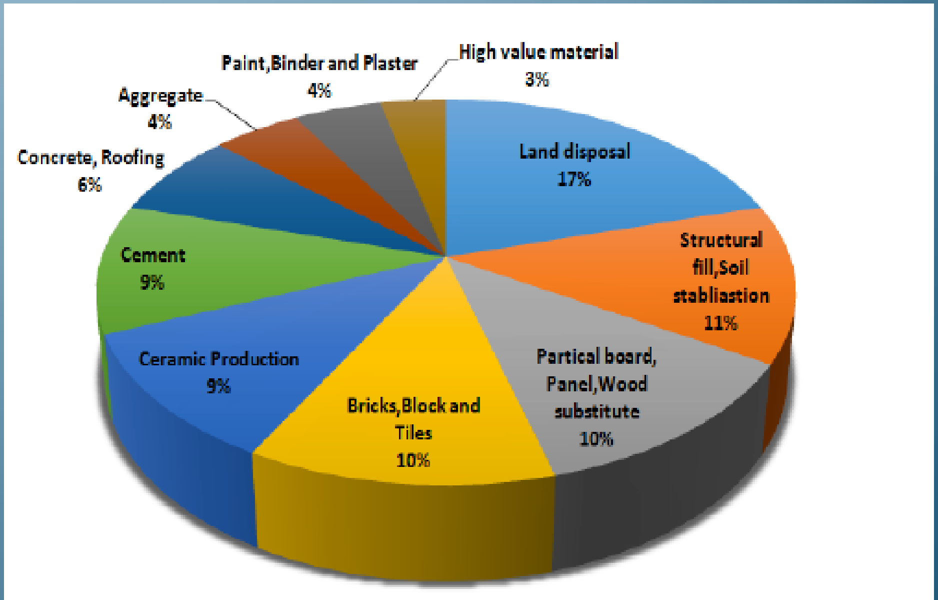
Social indicators:

- Direct and indirect employment
- Risks of accidents

RECYCLING OF NATURAL STONES SLURRIES

The processing (sawing, cut and finishing) of marble and granite stone generates large quantities of sludge which have the potential for a broad range of applications in a number of sectors, including:

- Cement manufacture
- Concrete products
- Ceramics
- Bricks, block and tiles (including agglomerated stone)
- Plaster boards panel and wood sustitute
- Structural fill and soil stabilisation
- Disposal site liners



1. CEMENT INDUSTRY

Main advantages:

- Extremely high demand of crushed limestone for the production of cement
- Micronized limestone+clays minerals are calcined together to produce the paste of the cement
- It is not crucial the water content of the slurries used as raw material because those slurries will be calcined
- A basic control for controlling the composition is needed in order to avoid the introduction of other minerals.

Main disadvantages:

- The economic feasibility of the recycling process will depend on the distance between the natural stone plants (where the slurries are produced) and the cement plants. Distance should be short to make the product attractive for this sector.

2. SELF COMPACTED CONCRETE INDUSTRY:

Main advantages:

- Valorized slurries could be used as filler to increase the paste volume
- The properties of the products are equivalent to the characteristics of the products performed using crushed limestone
- The increment of the filler content reduces the addition of other additives
- Part of the cement could be successfully substituted by fillers without a loss on the properties of the SCC
- The addition of slurries as raw material in the fabrication of SCC have shown very promising results at laboratory scale

Main disadvantages:

- Slurries will need previous treatments for characterization and valorization to ensure the quality of the product as raw material. The economical feasibility of the slurries as raw material will be influenced by the cost of the valorization processes.

3. AGGLOMERATED STONE INDUSTRY:

Main advantages:

- Agglomerated stone (artificial stone) are high added value products with a high demand in the construction market.
- Those products are formed by resin (6-10%) and aggregates+fillers (90-94%) and could be either siliceous or carbonatic composites
- Therefore slurries from processing granite or marble may be suitable to be used as filler
- In those case where the used resin are water-borne resins, it is not necessary the drying process
- Natural color of the slurries could benefited the products because new color could be obtained for the products without adding pigments

Main disadvantages:

- Products produced with wet slurries shown longer hardening times and lower mechanical properties, so drying processes may be recommended.

4. STRUCTURAL CERAMIC INDUSTRY (INCLUDING BRICKS AND TILES):

Main advantages:
- An strong and continuous demand of raw materials
- All types of mud can be utilized as additive to the structural ceramic paste to correct the expansion due to humidity
- Humidity is not so important factor for determining the feasibility of the process
- Mechanical properties are slightly lower but generally accepted by the in force normative

Main disadvantage:
- The content on Fe2O3 makes the slurries not suitable for fine ceramics applications
- Several factors control the economical feasibility of the processes due to mainly the very low cost of the conventional raw materials.

5. COATINGS, PLASTERS and PAINTS:

Main advantages:

- An strong and continuous demand of raw materials
- Low oil adsorption High brightness pH stabilization (only for carbonatic slurry)
- Good workability of final product
- High percentages in the mix
- Grain size distribution suitable for coating uses

Main disadvantage:

- High quality slurry (homogeneous colour and grain size distribution).
- Availability of a consolidated supply chain
- Use of additives and bonding agents (vinilyc and epoxydic compounds)

4. STRUCTURAL CERAMIC INDUSTRY (INCLUDING BRICKS AND TILES):

Main advantages:

- An strong and continuous demand of raw materials
- All types of mud can be utilized as additive to the structural ceramic paste to correct the expansion due to humidity
- Humidity is not so important factor for determining the feasibility of the process
- Mechanical properties are slightly lower but generally accepted by the in force normative

Main disadvantage:

- The content on Fe_2O_3 makes the slurries not suitable for fine ceramics applications
- Several factors control the economical feasibility of the processes due to mainly the very low cost of the conventional raw materials.

	Indicator	Possible applications				
		1	2	3	4	5
Environmental	Specific volume of stone waste managed	↑	↑	→	→	↑
	Water consumption *	→	↑	→	→	→
	Energy Consumption*	↑	↑	→	↑	→
	Chemicals/Reagents consumption and use of dangerous substances *	↓	↓	↑	↓	↑
	Transport constraints (average distance)	→	→	→	→	→
	Environmental incidents	↓	↓	→	↓	→

1


2


3


4


5


* In the pre-treatment phase and manufacturing (of final product)

Score: ↑ High → Medium ↓ Low

	Indicator	Possible applications				
		1	2	3	4	5
Economic	Overall indicative treatment and handling costs	↑	↑	↓	→	↓
	Indicative capital costs of waste management facilities	↓	↓	↓	↓	↓
	Indicative savings from landfill fees and rehabilitation costs	↑	↑	↑	↑	↑
	Total R&D expenditure/turnover *	↓	↓	↑	↓	↑
	Profit making/Added value *	→	→	↑	→	↑

1 

2 

3 

4 

5 

* In the pre-treatment phase and manufacturing (of final product)

Score: ↑ High → Medium ↓ Low

	Indicator	Possible applications				
		1	2	3	4	5
Social	**Direct and indirect employment ***	↓	↓	→	→	↑
	Risk for accidents *	↓	↓	↓	↓	↓

* In the pre-treatment phase and manufacturing (of final product)

Score: ↑ High → Medium ↓ Low

1

2

3

4

5

CONCLUSIONS:

- Several industrial sectors are nowadays demanding micronized mineral fillers for performing their products with similar characteristics to the slurries generated during the processing of natural stone

- In order to select the most appropriate option for waste recycling several factors should be considered

- The most important factor is the suitability of the material properties for the foreseen option

- The energy consumption and the treatment cost are issues that need to be carefully evaluated in order to calculated the added value of recovered waste

- The equilibrium between valorisation costs and conventional costs of the raw materials is critic in order to assure the economical feasibility of the process, for this reason social and political support may be required to promote the recycling process