A study on best available techniques for the management of stone wastes

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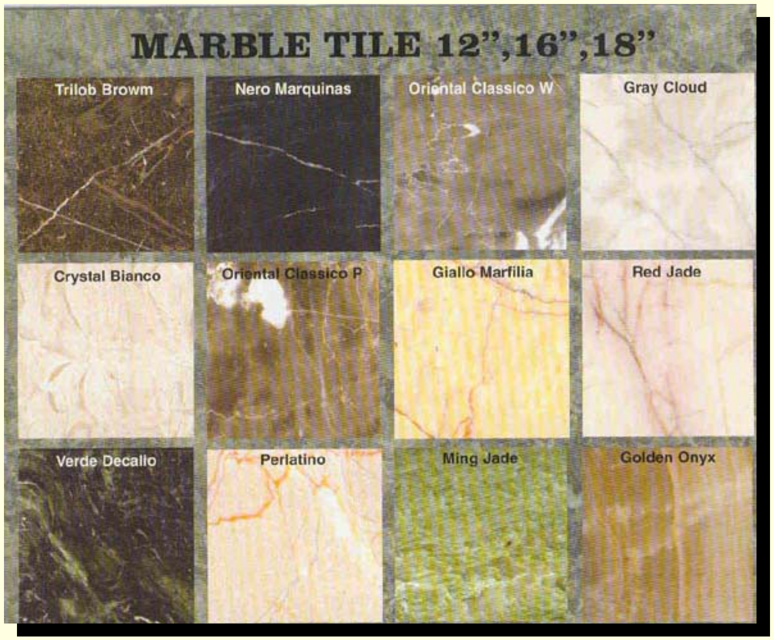
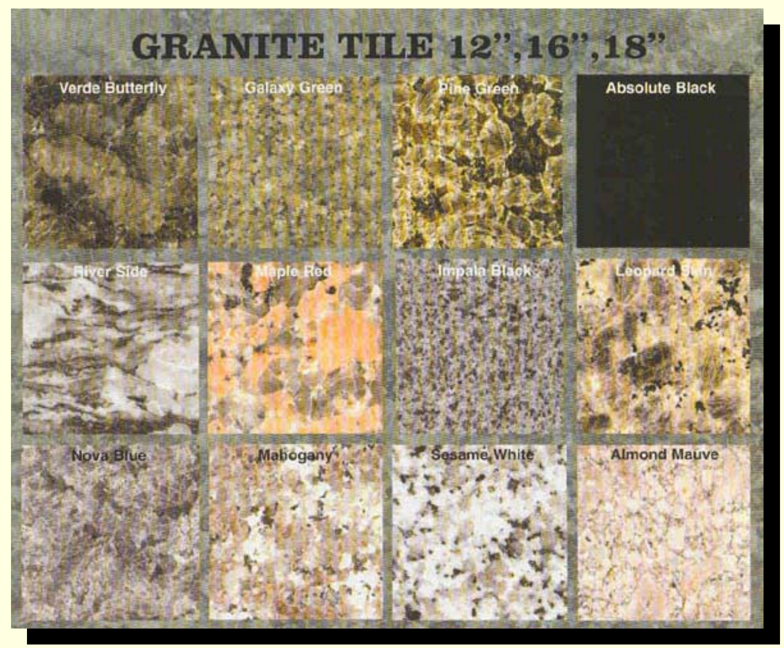
3rd International Conference on Sustainable Development Indicators in the Minerals Industry, June 2007, Milos island, Greece

Introduction – Natural stone



- Marble: commercial name for a wide family of calcareous rocks considered soft rocks



- Granite: commercial name for a wide family of siliceous rocks, considered hard rocks

Introduction – Stone industry

- Basic phases
  - Quarrying
  - Processing

Introduction

- Product of quarrying:

  Commercial block of stone

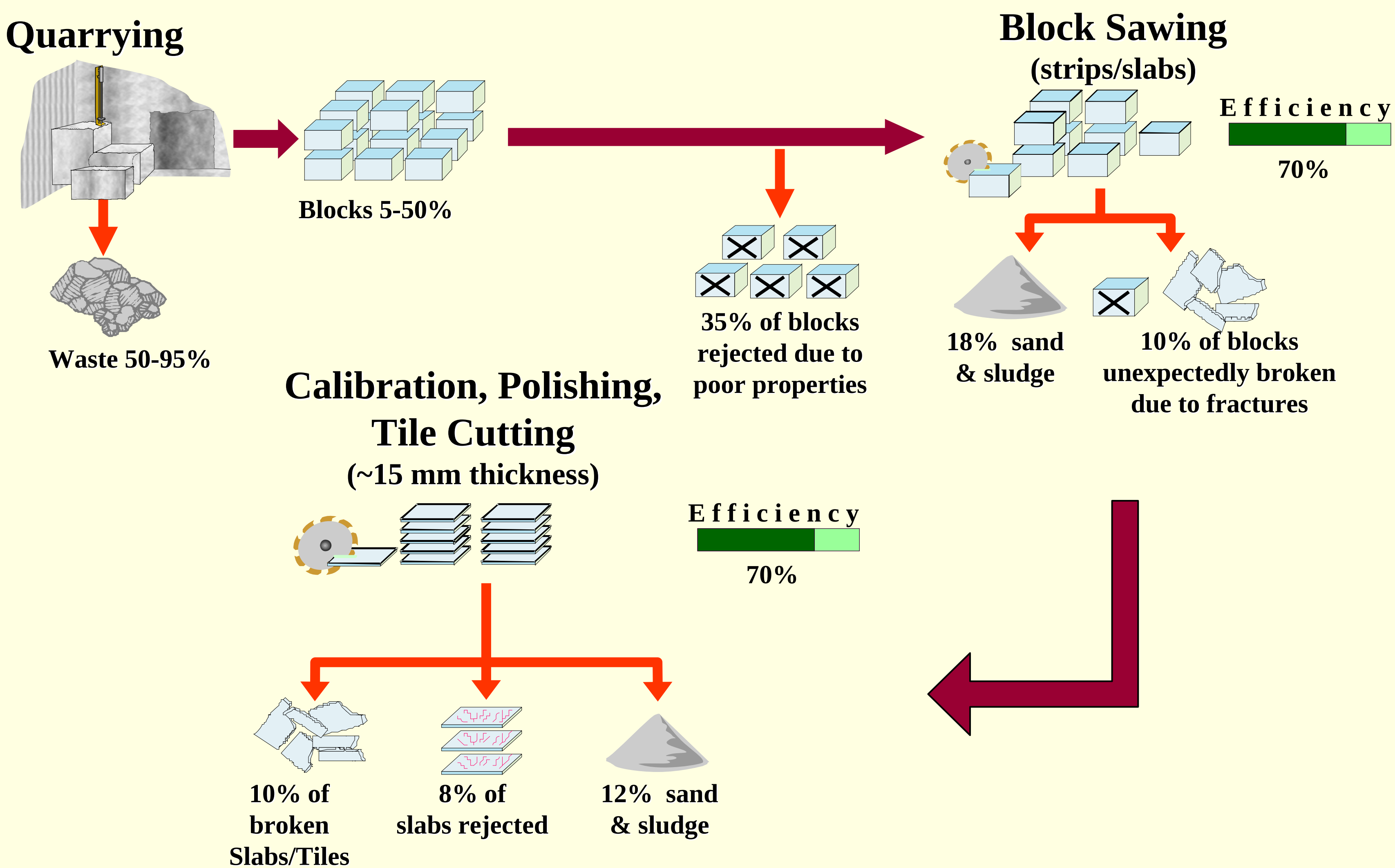
  (1.5 x 1.4 x 2.8 m)

Introduction

- Main products of processing phase:

Product	Length (m)	Width (m)	Thickness (mm)
Slab	2.5 – 3.5	1.3 – 2.0	20 - 80
Strip	1.0 – 3.5	0.15 – 0.65	10 - 50
Tile	0.15 – 0.65	0.15 – 0.65	10 - 12
Super thin tile	0.15 – 0.65	0.15 – 0.65	< 10

Introduction – Stone production chain



The problem of stone exploitation

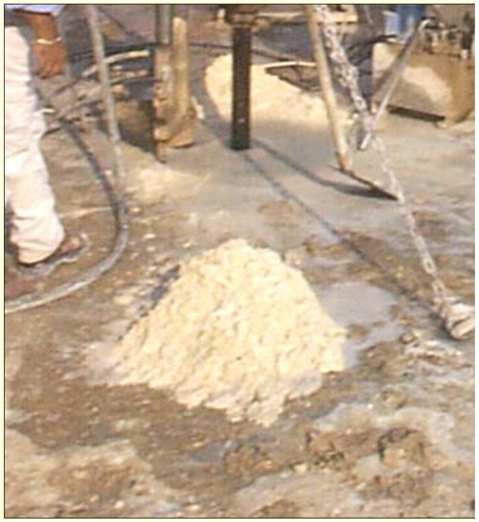
- Stone wastes are generated in huge quantities
  - Quarrying activities: 50% to 95%
  - Processing activities: 30% to 40 %

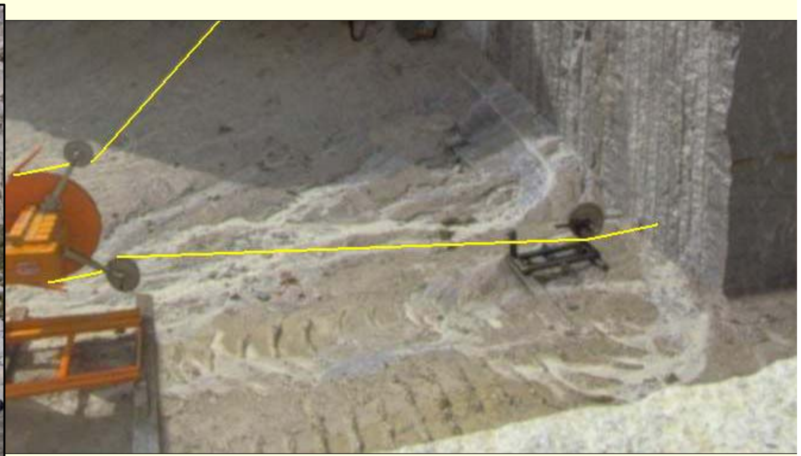
World data for 2003, Stone 2004

Activity	Parameter	ton	%
Quarrying	gross extraction	153,750,000	100
	net extraction	75,000,000	49
	quarry waste	**78,750,000**	**51**
Processing	gross processed	75,000,000	100
	net production	44,250,000	59
	processing waste	**30,750,000**	**41**

Stone waste types

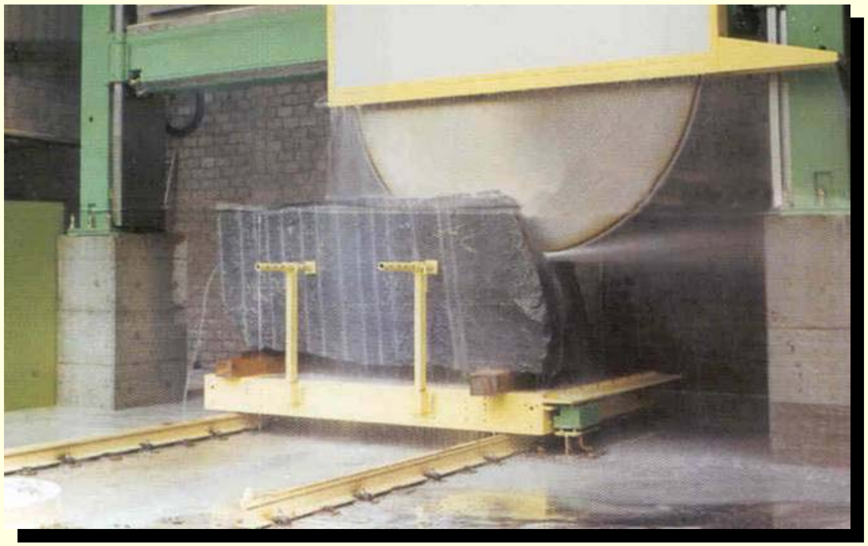
- Quarrying waste types:
  - Defective or “third choice” blocks
  - Large irregular blocks ($\geq 0.2\ m^3$)
  - Small irregular blocks (dimension < 0.5 m)
  - Small particles (splints, chips), and fine size sand and slurry





Stone waste types

- Processing waste types
  - 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.



Properties of stone wastes

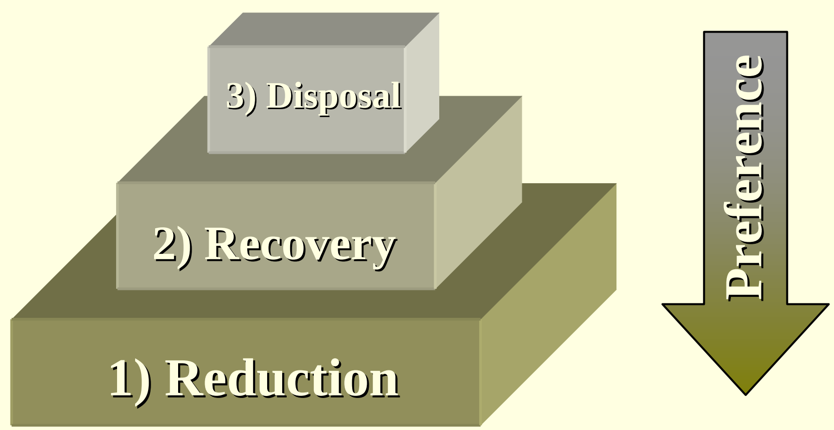
- Stone waste is inert material since it originates from the same stone deposit as the products.
- Stone waste does not have adequate properties to be used for ornamental and dimensional purposes
- But can be used in a variety of other uses with proper management

Waste Management - General

- Waste management aims at:
  - the reduction of waste
- This is achieved through:
  - the modification of productive processes to adopt cleaner technologies
  - the reuse of waste materials

Waste Management Hierarchy

- Hierarchy according to directive 91/156/EEC:
  - Prevention or reduction of waste production;
  - Recovery of wastes by means of recycling, re-use, reclamation or any other process;
  - Safe disposal of wastes.



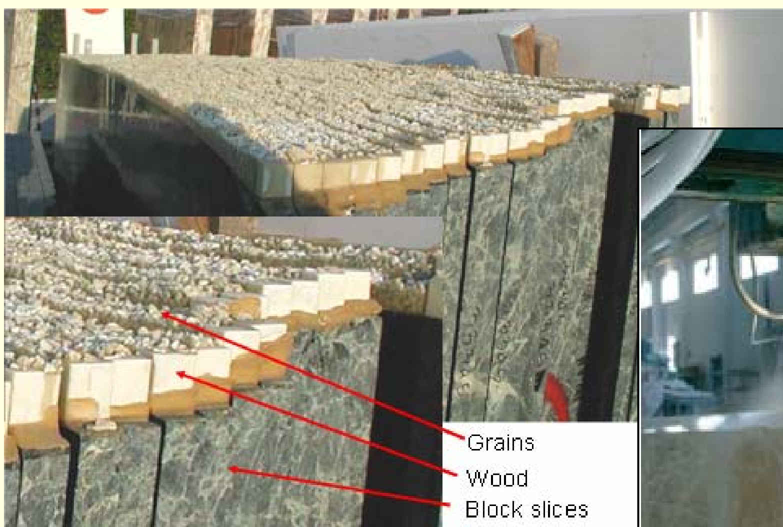
Waste management hierarchy as a pyramid of preference (European Council, 1991).

1st Level: Waste reduction

- Best available techniques for quarries:
  - Using of clean technologies like diamond tools, ramps and access roads,
  - Adopting exploitation methods like underground quarrying

1st Level: Waste reduction

- Best available techniques for processing plants:
  - Reinforcement of mechanically unsound blocks
  - Thinner cutting disks
  - Recycle of slurries with decantation and pressing

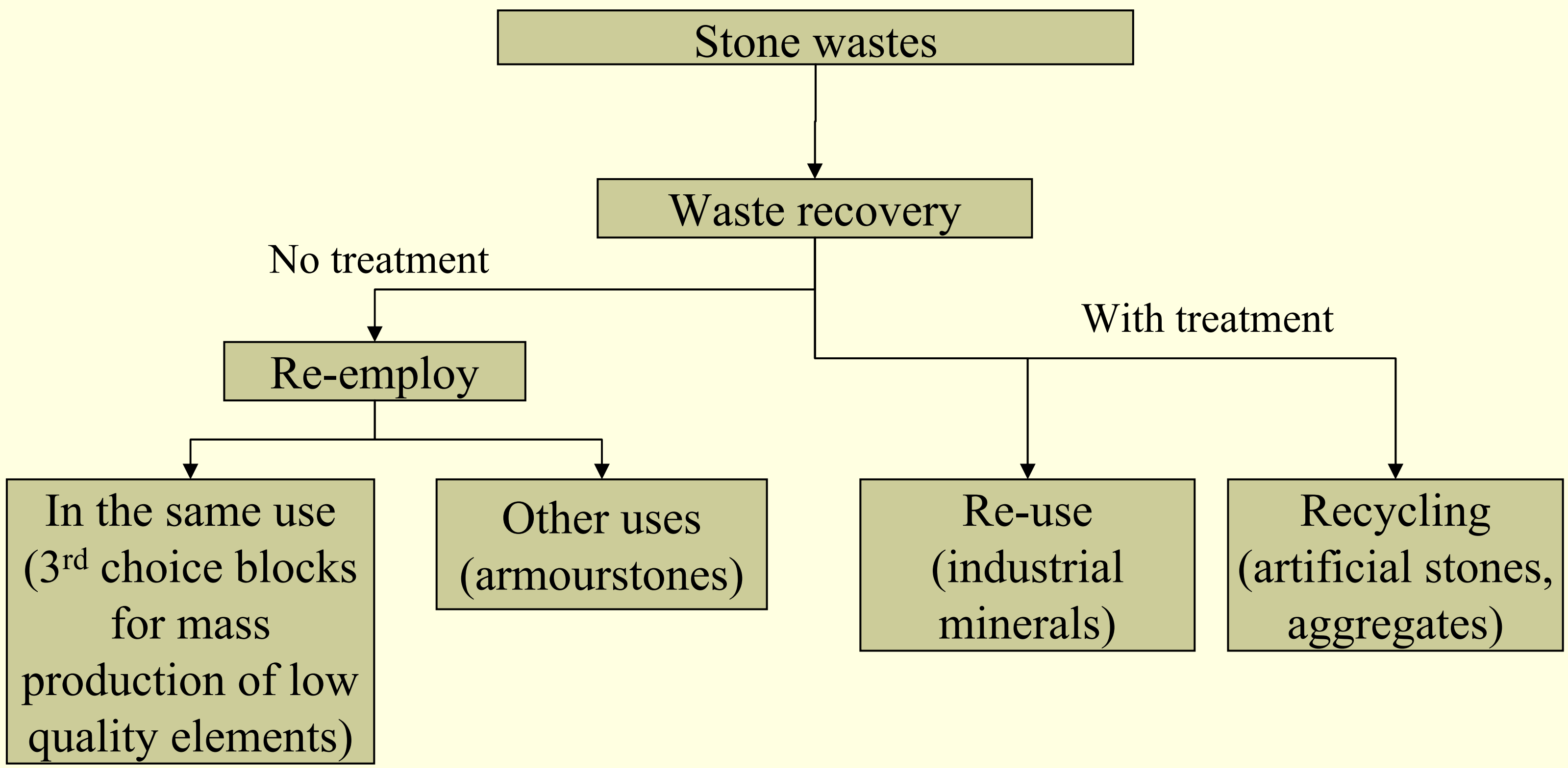


Reduction of wastes at the source

- Why the use of these techniques promotes the sustainability of the stone industry?
  - Create less waste
  - Need less energy
  - Less land use
  - Less visual disturbance
  - Less rehabilitation costs

2nd Level: Waste recovery

- Options for waste recovery



Best available techniques according to waste type

- Recovery of quarry wastes:
  - *third choice blocks:*
    - low price elements for external uses
    - stored and occasionally processed for large quantities of elements without high quality standards
  - *large shapeless blocks:*
    - armourstone,
    - aggregates
  - *small shapeless blocks:*
    - aggregates
  - *small to fine size particles:*
    - construction admixtures, plasters and mortars

Best available techniques

- Recovery of processing wastes:
  - *Scrap:*
    - choice scraps low-cost rustic floorings and coverings, generally for outdoor applications
    - non-choice scraps can be crushed for aggregate production
  - *Splints, chips:*
    - used for aggregate
    - as land-fillers for agricultural purposes

Best available techniques

- *Calcareous sludge* can be used to:
  - neutralize acidic industry by-products or contaminated agricultural land
  - de-sulphurise the fumes produced by high-power thermoelectric plants
  - as additive in hydraulic mixtures, plasters.
  - produce paper fillers, polymeric fillers (PVC), water paints, artificial stones.
- *Granite sludge* produced by disk saws or by the polishing process can be used in:
  - ceramic industry
  - moulding of plastics (PVC) when the inert material does not need to be calcareous.

3rd Level: Safe disposal

- The best techniques include the:
  - Common disposal sites for quarry clusters
  - Careful selection of disposal site
  - Backfilling if possible
  - Special treatment of sludge
    - Special zones for storage and treatment
    - Transportation of mud by specialized companies

Application of Sustainable Indicators

- Assessment before selecting a recovery option should be carried out
- The assessment of the performance of a waste recovery option is very case sensitive due to the plethora of factors that affect it
- Indicators can be established to assess sustainability
- The established SDIs are divided in 3 categories:
  - Environmental (i.e. energy, transport, etc.)
  - Economical (i.e. cost, added value, etc.)
  - Social (i.e. new jobs created)

Sustainable indicators

- Environmental indicators:
  1. Specific volume of stone waste managed
  2. Indicative water consumption during treatment per tonne of stone waste
  3. Energy consumption
  4. Chemicals/Reagents consumption
  5. Use of dangerous substances (reagents, chemicals)
  6. Transport constraints (average distance that can be covered from source to customers)
  7. Environmental incidents (reportable)

Sustainable indicators

- Economical indicators:
  1. Overall indicative treatment and handling costs
  2. Indicative capital costs of waste management facilities (if applicable)
  3. Indicative savings from landfill fees and rehabilitation costs
  4. Total R&D expenditure/turnover
  5. Profit making/Added value

Sustainable indicators

- Social indicators
  - Direct and indirect employment
  - Risks of accidents
- Based on these SDIs, some of the best available options for waste recovery are evaluated on a qualitative sense in order to demonstrate their application

Re-employ of quarry wastes

- in those uses that the material properties and size allow it (no treatment needed)
  - large shapeless blocks can be used as armourstone
  - 3rd choice blocks can be used for mass production of low quality elements (footpaths, cobblestone, dry wall)

Milford end of Hurst Castle Spit

Dry wall

Re-employ of quarry wastes

- Indicative SDI assessment for armourstone:

Category	Indicator	Value
Environmental	Specific volume of stone waste managed	Variable, depending on the waste quality and end-use requirements.
	Energy consumption	Low energy consumption for handling
	Transport (average distance)	Low to High: Depending on the stone size, the price of armour stone may enable it to be transported to regional or national markets and still remain economically viable.
Economic	Overall indicative treatment and handling costs	Low, Potentially high transport costs.
	Profit making/Added value	Low - High price: profit increases with size
Social	Direct and indirect employment	Variable, depending on production rate
	Risk for accidents	Low

Re-employ of quarry wastes

- Indicative SDI assessment for footpaths, drywall:

Category	Indicator	Value
Environmental	Specific volume of stone waste managed	Low-Medium: depending on the local market demand
	Energy consumption	Low: for handling.
	Transport constraints (average distance)	Low: Transportation will generally be limited to local markets; however special stone characteristics may enable economical access to regional markets.
Economic	Overall indicative treatment and handling costs	Low: for handling
	Profit making/Added value	Low price €/t but proportional to the volume of material used
Social	Direct and indirect employment	Variable, depending on production rate
	Risk for accidents	Low

Re-employ of processing wastes

- in those uses that the material properties and size allow it (no treatment needed)
  - i.e.: *large to medium sized scraps* can be used for low cost floorings and coverings for external applications

Re-employ of processing wastes

- Indicative SDI assessment for external coverings:

Category	Indicator	Value
Environmental	Specific volume of stone waste managed	Low - Medium, depending on the market demands
	Energy consumption	Low - Medium: for handling, selection
	Transport constraints (average distance)	Low - Medium: Transportation limited to local markets; however special stone characteristics may enable economical access to regional markets.
Economic	Overall indicative treatment and handling costs	Low-Medium handling and transportation cost
	Profit making/Added value	Medium price (up to €5-8/m^2) depending on stone characteristics and the relative market
Social	Direct and indirect employment	Variable, depending on production rate
	Risk for accidents	Low

Re-use of processing wastes

- In those uses that the material properties and size allow it (after treatment):
  - i.e. crushing and pulverizing the stone waste (<90 microns – Carbonate waste only) to produce cement and quicklime

Re-use of processing wastes

- Indicative SDI assessment for cement and quicklime:

Category	Indicator	Value
Environmental	Specific volume of stone waste managed	High: Potential demand is high
	Energy consumption	Medium-High for waste processing.
	Transport constraints (average distance)	Medium-High: Carbonate wastes fetching a high price may be transported to regional or national markets and still remain economically viable
Economic	Overall indicative treatment and handling costs	Medium-High for waste material.
	Profit making/Added value	High price €/t
Social	Direct and indirect employment	Variable, depending on production rate
	Risk for accidents	Low – Medium

Re-cycle of quarry wastes

- Re-cycle of waste (after treatment) in those uses that the material properties and size allow it:
  - i.e. crushing the stone waste to produce aggregates for concrete or asphalt mixes

Re-cycle of quarry wastes

- Indicative SDI assessment for aggregates:

Category	Indicator	Value
Environmental	Specific volume of stone waste managed	Considerably variable depending on final aggregate requirements. All large to small waste material can be crushed.
	Energy consumption	Medium: Depends on the crusher plant size and production capacity.
	Transport constraints (average distance)	Low: Haulage of aggregates over long distance is not cost effective
Economic	Overall indicative treatment and handling costs	Medium treatment and handling costs.
	Profit making/Added value	Low - Medium price €/t but proportional to the volume used
Social	Direct and indirect employment	Variable, depending on production rate
	Risk for accidents	Low

Re-cycle of processing wastes

- Re-cycle of waste (after treatment) in those uses that the material properties and size allow it:
  - i.e. use the stone sludge to produce artificial stones and tiles

Re-cycle of quarry wastes

- Indicative SDI assessment for artificial stones and tiles:

Category	Indicator	Value
Environmental	Specific volume of stone waste managed	Low-Medium: Dependent on local and regional markets
	Energy consumption	Medium-High for: handling, processing
	Transport constraints (average distance)	Medium-High: Transport to markets at similar distances to those for natural stone.
Economic	Overall indicative treatment and handling costs	Medium-High: Dependent on processing method, cost of waste preparation, and binder cost.
	Profit making/Added value	Medium-High value €/t.
Social	Direct and indirect employment	Variable, depending on production rate
	Risk for accidents	Low

Conclusions

- Disposal of leftover natural stone should be considered the worst possible option
- Ways to recover the stone waste should be always sought out, for the sustainable development of stone industry
- In order to select the most appropriate option for waste recovery several factors should be considered
- The most important factor is the suitability of the material properties for the foreseen recovery option

Conclusions

- Two groups of BAT to manage stone material:
  - Equipment and processes that allow prevention and reduction of waste
  - Applications that permit re-employ, reuse and recycling
- Correct waste management is profitable for both human and the environment
- The concept of “stone waste” must be replaced by the concept of “leftover, usable stone material”

Conclusions

- The set of 14 SDI is adequate for the performance assessment of possible waste recovery options, accounting for a variety of factors

- It is proved that with the increase of treatment, the energy consumption and the treatment cost are increased but also the added value of recovered waste increases accordingly

The End

- The EC funded project I-STONE is acknowledged for this work. (www.istone.ntua.gr)
- Thank you for your attention!