

SUSTAINABLE ARCHITECTURE

SUSTAINABLE ARCHITECTURAL DEVELOPMENTS

SUSTAINABLE MATERIALS

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If we think about materials....





MATERIALS PROPERTIES

Construction materials

Manufactured for a specific purpose (Materials Technology)

- Thermal insulation
- Compression strength
- Elasticity
- ...

They improve interior comfort and habitability



ENVIRONMENTAL IMPACT OF CONSTRUCTION MATERIALS

Consumption of natural resources

Consumption of energy

Emissions that are pollutant and dangerous for health

Impact on ecosystems



ENVIRONMENTAL IMPACT OF CONSTRUCTION MATERIALS

- Assessed through the product life cycle:
 1. Mining / extraction
 2. Manufacture
 3. Construction
 4. Operation and maintenance
 5. Demolition
- Two types of assessments:
 - Generic
 - Proprietary



ENVIRONMENTAL IMPACT OF CONSTRUCTION MATERIALS

- Most commonly considered impacts:
 - Climate change / embodied carbon
 - Acidification
 - Eutrophication
 - Stratospheric Ozone Depletion
 - Photochemical Ozone Creation
- Can also consider:
 - Renewable and non-renewable primary energy
 - Water consumption
 - Waste for disposal
 - Toxicity to ecosystems & humans
 - Resource depletion



CRITERIA FOR THE SELECTION OF SUSTAINABLE MATERIALS

Sustainable Material

“That one which causes less damage to the environment”

What criteria can we choose for material selection?



CRITERIA FOR THE SELECTION OF SUSTAINABLE MATERIALS

Sustainable Material

“That one which causes less damage to the environment”

Caracteristics for materials selection:

1. Natural materials
2. Low embodied energy materials
3. Non-detrimental-to-health materials
4. Materials recovery



1. Natural materials

Most important characteristics:

- Easy to obtain
- Good longevity
- No need of complicated technology to use
- High thermal mass
- Extraction for local resources
- Safe and easy return to the environment



1. Natural materials

EARTH

- Gives stability, compression strength and long lifespan
- Clay content needed (about 20%)
- Use in:
 - Walls
 - Rendering
 - Pavement



1. Natural materials

EARTH

Adobe



Mix of clay and straw



Put material inside mould



Build the wall



1. Natural materials

EARTH

Compressed earth blocks



SUPERADOBE

<http://www.calearth.es/superadobe/>



1. Natural materials

EARTH

Rammed earth



SUPERADOBE

<http://www.calearth.es/superadobe/>



1. Natural materials

EARTH

Superadobe



<http://www.calearth.org/intro-superadobe/>



1. Natural materials

EARTH

Comments:

- Not for wet climate or seismic areas
- Surface deteriorated easily, permanent maintenance
- Rendering. Never mix with cement. Problems with retraction, elasticity and permeability



1. Natural materials

CLAY

- Cohesion forces: increases stability and resistance
- Use in:
 - Adobe (mixed with straw)
 - Firing – ceramics





1. Natural materials

STONE

- Much mechanical resistance and lifespan
- Heavy construction
- Use in:
 - Foundation
 - Walls
 - Masonry
 - With and without any binder/mortar



<https://www.youtube.com/watch?v=aRvzapleXJ4>



1. Natural materials

TIMBER

- Organic material
- Good flexural strength
- Good thermal insulation (not good thermal mass)
- Easy to cut, work and carve
- Danger of decomposition (moisture and insect/plants attack)
- Fire can destroy it
- Use in:
 - Beams
 - Boards
 - Bearing elements
 - Walls
 - Cladding
 - Doors and windows



1. Natural materials

TIMBER

More used:

Soft wood: pine, poplar, spruce

Hard wood: oak, ash

For outdoors: cypress, teak

For interior: spruce, cherry tree, poplar

Resistant to fungi and insects: cedar, mahogany

The best: use local timber





1. Natural materials

CANE/BAMBOO

- Light and flexible
- Same problems as timber
- Use in:
 - Construction of boards for roofing
 - Ceilings
 - Partitions
 - Internal reinforcement





1. Natural materials

CANE/BAMBOO



Roofing

Fencing





1. Natural materials

CANE/BAMBOO



Structural elements

Walls





1. Natural materials

LIME

- Oldest binder used – Used by Romans
- Binding characteristics
- Disinfecting
- Used in:
 - Wall consolidation
 - Mortars and concrete



HOT LIME

HYDRATED LIME

HYDRAULIC LIME



1. Natural materials

GYPSUM

- Binding characteristics
- Quick setting
- Very quick return to the environment
- Used in:
 - Plaster mortars and mixed mortars
 - Ceilings
 - Vaults, archs and stairs without any formwork
 - Interior rendering
 - Precast products
 - Ornamental elements



1. Natural materials

STRAW

- Wheat and corn pruning
- Once dried, attack from fungi and insects is reduced
- Big elasticity and flexibility
- Used in:
 - Interior reinforcement
 - Wall execution (straw bales)



1. Natural materials

STRAW



Framed



Without frame



1. Natural materials

STRAW



El Faro. Expo Zaragoza 2008



1. Natural materials

STRAW





1. Natural materials

RESTORATION AND RETROFITTING OF OLD BUILDINGS

What problems can we have when combining traditional and modern materials?

How can it affect the building performance if we change traditional materials with modern materials?



1. Natural materials

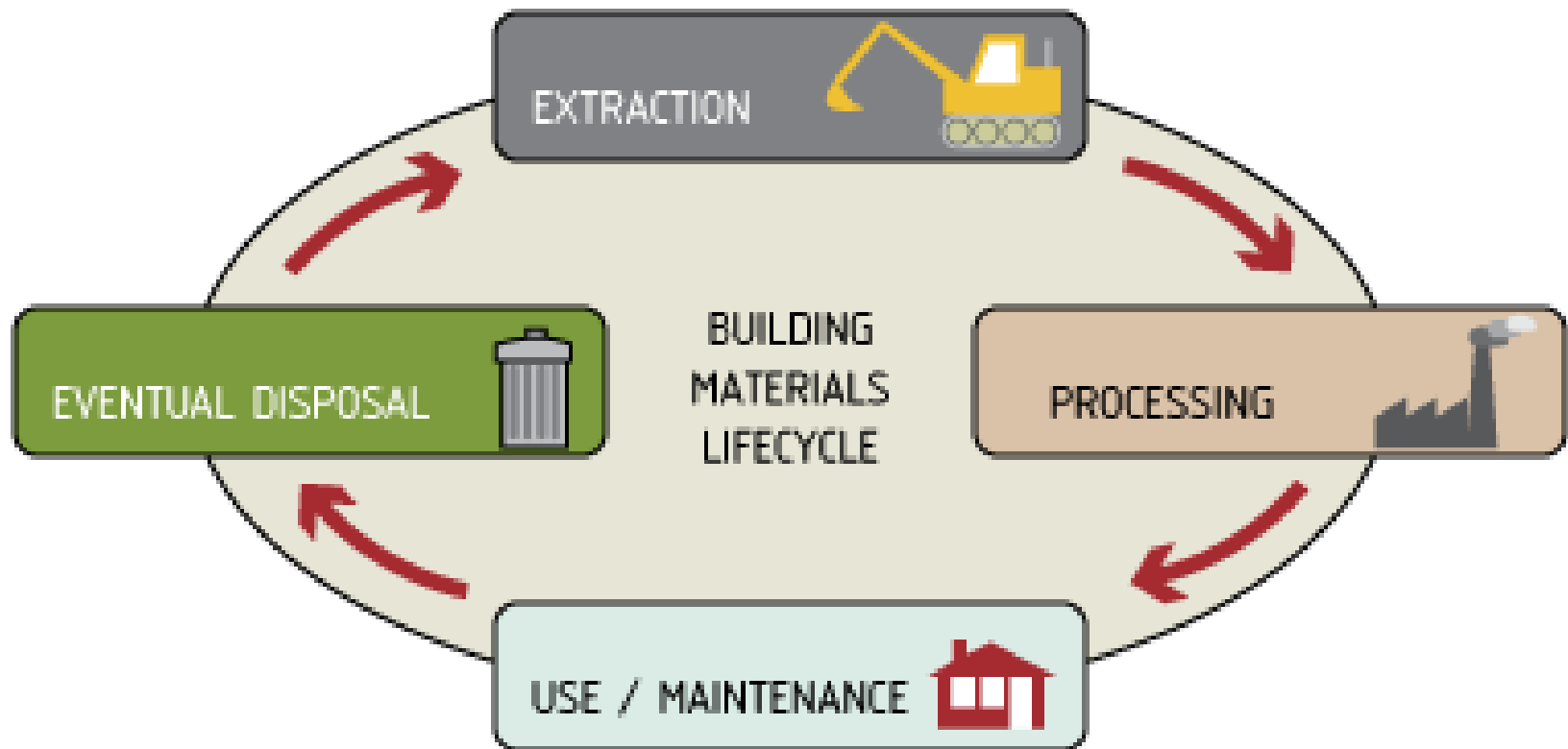
RESPONSIBLE SOURCING MATERIALS

Read the document given and answer the following questions:

- Why is responsible sourcing materials so important?
- What does FSC certificate?
- What is BES 6001?
- What areas of assessment are considered?



2. Materials with low embedded energy





2. Materials with low embedded energy

Characteristics:

- Few physical and/or chemical transformations
- Reduction of transport
- Use of local materials
- Good properties during useful life
- Materials recovery



2. Materials with low embedded energy

MATERIAL	EMBEDDED PRIMARY ENERGY (MJ/Kg)
Steel in the market (20% recycled)	35
100% recycled steel (hypothetical)	17
Primary aluminium	215
100% recycled aluminium (hyp)	23
Aluminium in the market (30% recycled)	160
Fired clay, bricks and roof tiles	4,5
Fired clay, vitrified ceramics	10
Fired clay, sanitaryware	27,5
Sand and gravel	0,1
Tar paper	10
Cement	7



2. Materials with low embedded energy

MATERIAL	EMBEDDED PRIMARY ENERGY (MJ/Kg)
Fibre-cement (asbestos)	6
Fibre-cement (synthetic fibre or wooden)	9
Glass-fibre	30
Timber	3
MDF	14
Paint	20
Varnish	100
PVC	80
Polystyrene	100
Glass	19
Plaster	3,3



2. Materials with low embedded energy

MATERIAL	EMBEDDED PRIMARY ENERGY (MJ/Kg)
Mortar	1-1,3
Concrete	1-1,1

Extracted from “Guía de la Edificación Sostenible”, IDAE,
Spanish Ministry of Development and Institut Cerdà, 1999



2. Materials with low embedded energy

Parts assessed in an LCA

- Cradle to gate
- Cradle to site
- Cradle to grave





2. Materials with low embedded energy

Environmental Product Declarations BS EN 15804:2012+A1:2013

Information of the building life cycle									Additional information beyond the life cycle
A1-A3 Product stage	A4-A5 Construction stage		B1-B7 Use stage					C1-C4 End of life stage	D Benefits and loads beyond the system limit
A1 Supply of raw materials A2 Transport A3 Production	A4 Transport	A5 Construction/installation process	B1 Use	B2 Maintenance	B3 Reparation	B4 Substitution	B5 Restoration	C1 Demolition/deconstruction C2 Transport C3 Waste treatment C4 Dumping	Potential to reuse , recuperateand recycle
			B6 Use of energy in-service						
			B7 Use of water in-service						



Green Guide to Specification

- Developed by BRE, part of BREEAM
- Contains specifications for buildings
- Examines the relative environmental impacts for generic building types:
 - Commercial buildings
 - Educational
 - Healthcare
 - Retail
 - Domestic
 - Industrial
- Environmental rankings based on LCA



Green Guide to Specification

- Materials arranged by element:
 - External walls
 - Internal walls and partitions
 - Roofs
 - Ground floors
 - Upper floors
 - Windows
 - Insulation
 - Landscaping
 - Floor finishes



Green Guide to Specification

Green Guide rating	Mat 01 points
A+	3
A	2
B	1
C	0.5
D	0.25
E	0



Other databases

<http://www.circularecology.com/embodied-energy-and-carbon-footprint-database.html#.WmsDX65l8dU>

<http://www.openlca.org/lca-data/>