Materials: stones

Sourcing

Stone materials are obtained from rocks. Rocks are made into blocks, tiles, granules, and fragments of different sizes.
They are used in architectural constructions, civil engineering constructions, ornamentation, etc.

Process

Some stone materials are used without hardly any transformation. We can summarize the process of sourcing in the following steps, which in many cases are done right in the quarry:

1. **Extraction.** In the quarry, the rocks are removed from the Earth's crust, with machines or with controlled explosions.
2. **Grinding.** Evenly-sized pieces are obtained.
3. **Cutting.** The blocks that are too big are cut to the right size.
4. **Smoothing.** The rocks are polished.
5. **Finishing.** Impurities that might have remained are eliminated.
6. **Storage.** They are prepared and stored for transport.
7. **Transport.** They are taken to the factory to be transformed.


Grinding process for obtaining gravel.

Properties of stones

Physical properties

- **Electrical conductivity**

Electrical conductivity is the ability of a material to let current flow through it. The higher the electrical conductivity of a material, the more easily charges travel through it.
Dry stone materials are good electrical insulators.

- **Thermal conductivity**

Thermal conductivity is the ability of a material to let heat pass through it.
The higher the thermal conductivity of a material, the more easily heat passes through it.
Dry stone materials are good thermal insulators.

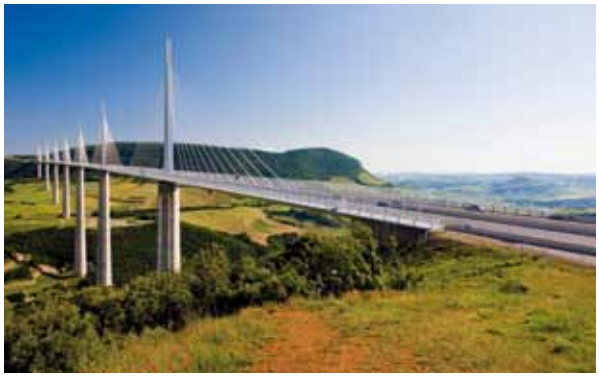
- **Density**

Density is the amount of material mass per unit of volume.
In general, the density of stone materials is high, higher than water.

- **Expansion**

Expansion is the relative variation in the dimensions of a material due to a change in temperature.

This must be taken into account in large civil engineering constructions, like bridges, housing, buildings, etc.



- **Melting point**

The **melting point** is the temperature at which a material goes from a solid state to a liquid state.
Each rock has a different melting point depending on its mineral composition, and it is usually very high.

- **Fusibility**

Fusibility is the property of materials that refers to the amount of heat required to melt them. In order to increase the temperature of a unit of mass of a material by one kelvin (degrees centigrade), a certain amount of heat is needed, which is different for each material. This amount is called the specific heat capacity.
Fusibility has to do with both the melting point and the specific heat capacity, as well as with other properties.

- **Hygroscopy**

Hygroscopy is the ability of a material to absorb humidity from the environment.
This is why materials intended for outdoor construction must be previously treated.

- **Porosity**

Porosity is the ratio of the volume of pores to the total volume of a material. Rocks are porous.

Mechanical properties

Types of stress

When forces of any kind act upon an object, we say that the object undergoes **stress**.
The reaction of a piece of a certain material subjected to stress depends on many factors: the intensity of the stress, the size of the piece, the material it is made of, and also the type of stress.
The following are the main types of stress:

- **Traction**

Traction is the stress a material is subjected to by two opposing forces that pull on it.
A stress of this type always increases the length of a piece in the direction of the forces, and if it strong enough, it reduces its cross section and will finally break it.

- **Compression**

Compression is the stress a material is subjected to by two opposing forces that push on it.
A stress of this type always reduces the length of the piece in the direction of the forces, and if it is strong enough, increases its cross section and will finally break it.

- **Bending**

Bending is the stress a material is subjected to by forces that try to bend it.
A stress of this type always makes the piece curve, and if it is strong enough, will finally break it.

- **Shearing**

Shearing is the stress a material is subjected to by two opposing forces acting on different points that are very close to each other, and try to cut the piece.
A stress of this type always produces deformations in the piece, and if it is strong enough, will finally break it.

- **Torsion**

Torsion is the stress a material is subjected to by two forces which try to twist it around an axis.
A stress of this type always produces deformations in the piece, and if it is strong enough, will finally break it.

Response to stress

Each material responds in a particular way to different types of stress, depending on their intensity.
Despite these differences, some general conclusions can be drawn. As the intensity of the stress increases, materials first display their **elastic properties**, then their **plastic properties**, and finally their **resistance properties.**

- **Elasticity**

Elasticity is the ability of a material to deform when it undergoes stress and then to return to its original shape when the stress is removed.
A material behaves elastically when it undergoes low-intensity stress to a certain limit, called the **yield point**, which is different for each material. If this is limit is exceeded, the deformation becomes permanent and the material could break.

- **Plasticity**

Plasticity is the ability of a material to remain deformed by a stress when the stress is removed.
A material behaves plastically when it undergoes stress of an intensity that is higher than its yield point for the specific type of stress.
Ductile materials are used to produce bars and wires.

- **Resistance**

Resistance is the ability of a material to undergo stress without breaking.
No matter what type of material and the type of stress applied, all materials will eventually break. In regards to resistance, the only thing that matters is the intensity of the stress applied.
Materials that bear high-intensity stress without breaking are very resistant and materials that break under low-intensity stress are not very resistant.

Other mechanical properties

- **Hardness**

Hardness is the ability of a material to resist being scratched or punctured.

- **Toughness**

Toughness is the ability of a material to resist breaking when it is hit.
In general, the response of a material to sudden stress is different than when the stress is applied gradually. Therefore, this response is defined by properties other than elasticity, plasticity, and resistance. One of these other properties is **toughness**.

When a material is not very tough, meaning it breaks easily when hit, we say it is **fragile**.


Granite columns.

- **Fatigue**

Fatigue is the property of a material to lose resistance to breaking when subjected to repeated stress.
Neither do materials behave the same way when stress is applied repeatedly. In general, more intense stress is needed to break a piece when applied once than when applied repeatedly.

- **Machinability**

This varies a lot, as it not only depends on physical properties and on certain mechanical properties, but also on other more practical issues.

- **Weldability**

Weldability is the ability of a material to join solidly with another piece when heated, and if needed, with other additional materials.

Chemical properties

Chemical properties are the behavior of a material when it comes in contact with other substances.

- **Permeability**

Permeability is the ability of a material to let water or other fluids pass through them.

- **Solubility**

Solubility is the ability of a material to mix homogeneously with another substance, acting as a solvent.

- **Oxidation**

Oxidation is the ability of a material to combine with oxygen, forming a layer of oxide on its surface.

Biological properties

Biological properties are the effects that a material has on living organisms and the environment.

- **Recyclability**

Recyclability refers to our ability to transform a used product into another product with a new useful life.
In general, the new product is not of the same type as the previous one.
It is important to emphasize that the recyclability of a material depends basically on our technical capacities. Many materials that could not be recycled in the past, now can.

- **Biodegradability**

Biodegradability is the ability of a material to decompose as a consequence of interactions with the environment.

- **Toxicity**

Toxicity is the ability of a material to produce negative effects on living organisms.

Classification

Natural stone materials

Natural stone materials are used with hardly any transformation, just as they are extracted from the quarry.

- **Igneous or eruptive rocks:** Created by the solidification of magma.
- **Sedimentary rocks:** Created by the accumulation of other rocks as a result of atmospheric agents.
- **Metamorphic rocks:** Created from both igneous and sedimentary rocks, as a consequence of great pressure and high temperature in the lithosphere.

Igneous or eruptive rocks

Granite

- **Characteristics**

It is rock made mostly of quartz, feldspar, and mica. It is very abundant in the Earth's crust. It has different sizes of grains and resists weathering.

- **Uses**

Coverings, pavings, baseboards, countertops, columns, staircases, etc.

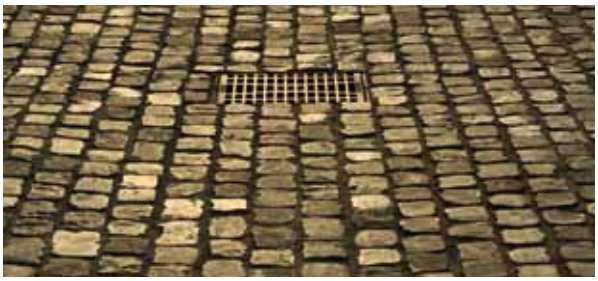
Basalt

- **Characteristics**

It is a compound rock. It is very abundant in the Earth's crust, fine-grained, dark-colored, and resistant to weathering.

- **Uses**

Pavings, coverings, decoration, monuments, sculptures, etc.



Basalt paving.

Sedimentary rocks

Gravel

- **Characteristics**

It is obtained from the natural or artificial fragmentation of other rocks, like granite, limestone, basalt, quartz, etc.

- **Uses**

Cover, level, and drain the ground; production of concrete.

Sandstone

- **Characteristics**

It is obtained from the natural or artificial fragmentation of other rocks, like quartz, gypsum, coral, feldspar, etc. It is very porous and can store a large amount of humidity.

- **Uses**

Production of concrete, ashlar, and masonry.

Clay

- **Characteristics**

It is created from the natural decomposition of rocks that contain feldspar. Its grains are tiny and its color depends on its impurities. In contact with water, it increases in volume and takes on plastic properties. It also has a large capacity to absorb water.

• **Uses**

Production of cement and ceramics.

Limestone

• **Characteristics**

It is a rock made up of calcite and impurities. It is easily attacked by acids.

• **Uses**

Production of cement, ashlar, and masonry.

Metamorphic rocks

Slate

• **Characteristics**

It is a rock that comes from metamorphosed clay. It is fine-grained, resistant to weathering, and can be easily laminated in thin sheets.

• **Uses**

Coverings, mainly roofings.

Laying of slate roofing tiles.

Marble

• **Characteristics**

It is a rock that comes from limestone, made up of calcite and impurities. It is resistant to weathering and is available in a great variety of colors.

• **Uses**

Sculpting, countertops, etc.

Transformed stone materials

Transformed stone materials are obtained from natural stone materials.

Ceramics

• **Characteristics**

They are obtained from clay, by molding it and firing it in an oven at high temperatures, and in general, melting stone materials. They have a high melting point, are good thermal and electrical insulators, and are resistant to weathering.

• **Uses**

Construction and ornamentation.

Binders

• **Characteristics**

They are able to join different elements through physical and chemical transformations, and bind them together.

• **Uses**

Joining material.

Ceramics

Ceramics are obtained from selected clays which are molded and fired at different temperatures.

Porous

- **Characteristics**

They are permeable and have an earthy, rough appearance when broken.

- **Uses**

Bricks, floor tiles, roof tiles, etc.

Impermeable

- **Characteristics**

They are impermeable and have a glass appearance when broken.

- **Uses**

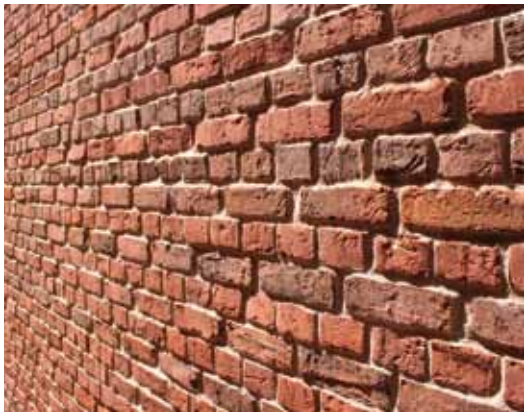
Glazed bricks, glazed tiles, dishes, etc.

Porous

Brick

- **Characteristics**

Piece that is a rectangular parallelepiped.



- **Uses**

Walls, arches, pillars, etc.

Roof tile

- **Characteristics**

Piece with a grooved shape, and can also be flat.

- **Uses**

Roofs

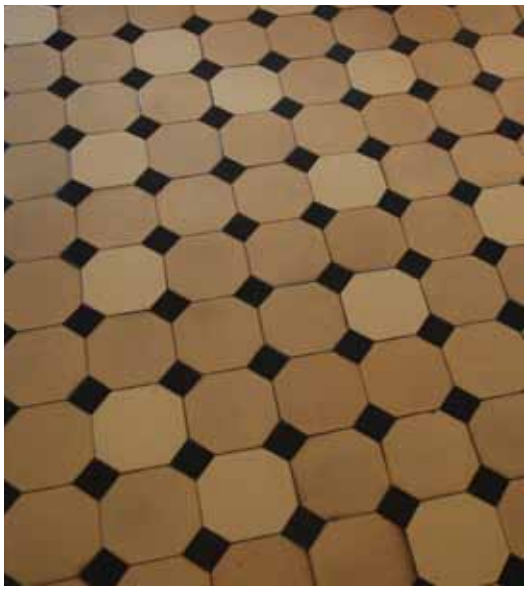
Floor and wall tile

- **Characteristics**

Piece with different shapes, designs, and finishes.

- **Uses**

Floors, walls, etc.



Pottery

- **Characteristics**

It is made from white clays which are fired, enameled, and fired again to achieve a shiny finish.

- **Uses**

Plates, cups, platters, vases, and sanitary fixtures, etc.

Refractory

- **Characteristics**

They withstand high temperatures without melting or deforming.

- **Uses**

Electroceramics, etc.

Impermeable

Glazed tile

• **Characteristics**

Thin piece with one side of fired clay to be stuck to the wall and the other of vitrified enamel which will be seen.

• **Uses**

Indoor and outdoor surfaces, decoration, etc.

Stoneware

• **Characteristics**

It is usually enameled and fired at very high temperatures. It is impermeable and resistant to weathering.

• **Uses**

Sanitary fixtures, electrical industry, walls, etc.

Porcelain

• **Characteristics**

It is molded and dried before firing at very high temperatures. It is impermeable, translucid, and resistant to weathering.

• **Uses**

Sanitary fixtures, electrical industry, decoration, dishes, etc.

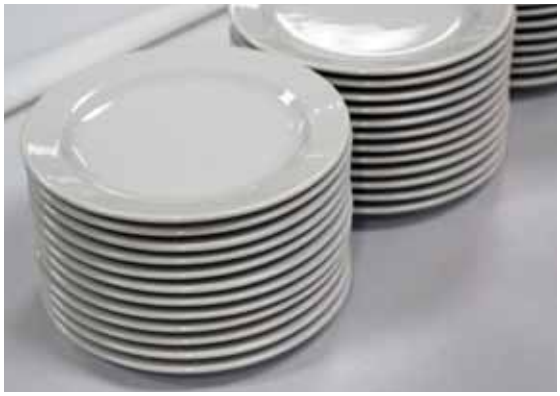
Glass

• **Characteristics**

It is made up of quartz sand and is molded at high temperatures. It is impermeable, a good thermal conductor, a good electrical insulator, and resistant to weathering.

• **Uses**

Windows, doors, lenses, mirrors, glasses, bottles, decoration, etc.



Binders

Cement

• **Characteristics**

It comes from clay, limestone, and other substances that are mixed, fired, and ground to obtain a very fine powder.

• **Uses**

It is most important in construction.

Lime

• **Characteristics**

It comes from limestone.

• **Uses**

Construction, ironworking, metalworking, chemical industry, production of sugar, fertilizer, water treatment, etc.

Plaster

- **Characteristics**

It comes from gypsum rock.

- **Uses**

Partition walls, ceilings, indoor and outdoor wall coverings, whitewash, sculptures, etc.

Joining materials

Joining materials are a mixture of binders, water, and in some cases, aggregates.

Plugging cement

- **Characteristics**

It has only an aggregate, a binder, and water.

- **Uses**

Whitewashing indoor and exterior walls, temporary joining of construction elements (tiles, handrails, door and window frames, etc.), stucco, etc.

Mortar

- **Characteristics**

It has one or more binders, water, and sand.

- **Uses**

Partition walls, joining of construction elements, restoration, brick walls, masonry, etc.

Concrete

- **Characteristics**

It has cement, water, sand, and gravel.

- **Uses**

Foundations, staircases, columns, walls, buildings and large constructions, etc.

Tools for stone materials

All the information contained in this section is available in the web version of the chapter.

Working with stone

Tool usage and safety

When working, the following rules must be observed:

- Good-quality tools must always be used.
- Tools must be used for the task for which they were designed.
- Tools must be kept clean and tidy.
- Measuring tools must be stored protected from the rest.
- Cutting tools must be well-sharpened. They should be kept in boxes or cases, with the cutting edge well-protected.
- The pieces must be firmly held in the bench vise or clamps of the machine tool.
- To tighten or loosen screws, the tool with the best fit must be used.
- The monkey wrench should only be used when there is no one-size wrench available that appropriately fits the head of the screw or nut to be tightened or loosened.

  Protective equipment (goggles, gloves, mask) must be used for tasks that would be dangerous to do without them.

- **Goggles**

They are normally made of resistant plastic. They protect eyes and parts of the face near them. They should be used whenever there is a risk of material flying up, for example, while drilling and grinding.

- **Gloves**

They are usually made of leather. They protect hands from cuts.

- **Mask**

It protects the airways in dusty environments. Its use is recommended while working with mortars, grinding, painting, or sweeping.

Curl and anchor plugs

A curl or anchor plug is a tube that is embedded in a wall or in a ceiling. A screw is inserted through them to hang an object.

- **Plastic**

When the screw is inserted in the plug, the rear part widens to hold it in place.

- **Metal**

When the screw and the plug are inserted in the hole, the rear part widens to hold them in place.

- **Adhesive or chemical**

The hole is filled with a chemical anchor and the screw is inserted. After a while, the resin hardens and the screw is held in place.

• **Flanges**

When the screw is inserted and turned, the flanges of the plug open and hold it in place.

Finishing techniques

Finishing entails the application of products to protect stone materials, and improve and change their appearance and texture.

• **Varnishes and lacquers**

They may be natural or synthetic, transparent, gloss, or matte. Once dry, they form a protective layer on the surface that resists humidity and small bumps.

• **Paints**

Their basic components are a dye or pigment and a binder.

• **Dyes and pigments**

Elements which provide color. They are produced with organic chemical materials in the form of powder or with certain metal oxides.

Binders

Chemical products (oils, resins) that when mixed with dyes, produce paint. They aid drying and adherence, and create a protective layer.

• **Priming**

Process previous to painting which aids adherence.

• **Stucco**

This is a process of covering walls with a paste, called stucco, which creates a protective layer on the surface.

Rules

Processes of dyeing, varnishing, and painting require care and following guidelines prior to the final process.

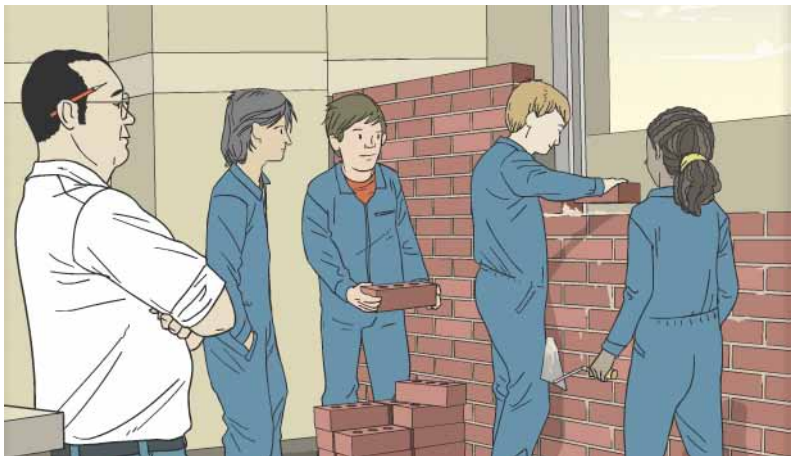
1. **Preparation of the surface**
   After finishing the surface, all remains of material and dirt must be removed.
2. **Protection**
   During the finishing process, protective equipment must be used.
3. **Priming**
   This consists of applying a sealant to the surface to improve adherence of the products applied later.
4. **Application of the product**
   This must be done with tools which are appropriate for the type of surface. If necessary, apply another layer after the first dries.
5. **Maintenance and cleaning**
   When the process is finished, clean the tools, let them dry, close the containers tightly, and store everything in its place.

Reduce, reuse, and recycle

The 3 Rs: stone materials and the environment

Notice how much stone materials are used around us: buildings, asphalt, windows, ceramics, etc.

• **Don't forget the rule of the 3 Rs: reduce, reuse, and recycle. This is your contribution to caring for the planet.**



Reduce

In order to reduce the amount of unnecessary waste created, materials must be used correctly.

As much as possible, try to:

- Not use machine tools if the task can be done by hand. This way we reduce energy consumption considerably.
- Reduce dust emission when making mortar.
- Not waste mortar. If we let it harden and later we need it, we will have to make more.

Reuse

Before starting a project, it is necessary to check what we need, what we have, and what we can use again.

As much as possible, try to:

- Not buy unnecessary materials. In some recycling points, we can find wall tiles, floor tiles, etc.
- Share materials with classmates.
- Reuse glass jars.
- Take the exact measurement of material needed.
- Generate less waste.

Recycle

Try to:

- Buy recyclable products.
- Place recyclable products in the boxes and bins as indicated.
- Take products that are not easily recycled (leftover mortar, tiles, hardened clay, etc.) to special collection points.