Department of Materials Engineering and Chemistry
Faculty of Civil Engineering

Building Materials

Lecture 10

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Exam

Date: 15.12. 13:00, A228

Total time: ca 2 - 3 hours

Written part:

1. **Test from general knowledge** - ca 20 min
   - 10 questions
   - short answers
   - no books or notes
   - terms, definitions, some chemical equations, properties and units, use of materials
   - no figures (exception were given at lectures), no commercial names, no numbers of standards
   - max. 10 points

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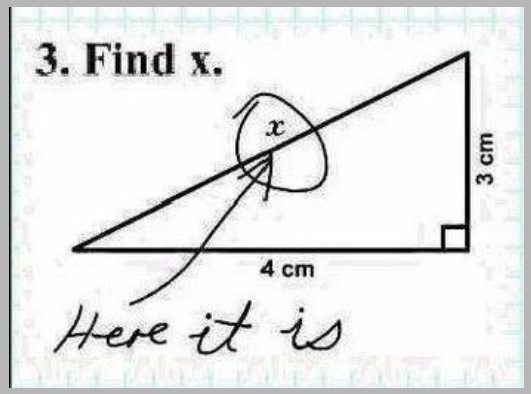
Exam



Written part:

2. **Calculations** - 45 min
   - calculators necessary! (no mobile phones!)
   - no books or notes
   - official aid - one paper with formulas and values (dowload from our web page)
   - 3 simple problems:
     - particle size distribution of mixture
     - physical properties (density, bulk density, moisture content, porosity, thermal elongation…)
     - mechanical properties (strength, modulus of elasticity...)

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Exam

Grading:

- **Test -** max. 10 points
  - **A** : 9-10 points
    B : 8 -8,5
    C : 7 -7,5
    D : 6 - 6,5
    E : 5 - 5,5
    F : under 5 points
- **Calculations**
  - **A** : 3 solved
  - **C** : 2 solved
  - **E** : 1 fully solved or partially solved all three problems
    B, D : + other partially solved problem

Exam

Oral part and results:

- 2 grades from the written part (e.g. B + D)
  - Satisfied with the worse grade? → No oral exam, worse grade is the final result of exam.
  - Want a better grade? → Oral exam - final result : ↑ ↓ =
  - One grade is F → Oral exam : ↑=
  - Both grades are F → ☹ New exam …

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Autoclaved products

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Autoclave curing

- curing of products in special vessels (**autoclaves**), with an environment of steam with high pressure and temperature
  - temperature ca **180 °C** and pressure **0,8 MPa**
- **hydrothermal hardening of silicate materials**
- final strength obtained after 16 -18 hours
- non-hydraulic binders became hydraulic
  - quartz sand reacts with calcium hydroxide to form calcium silica hydrate

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Aerated autoclaved concrete - AAC

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Aerated autoclaved concrete

Composition:

- **binder** (lime, cement)
- **silicate materials**
  - sand – white AAC
  - ash – grey AAC
- **gas forming (foaming) admixture**
  - Al powder, Al paste
- **water**

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Aerated autoclaved concrete

Foaming:

- $2\ Al + 3\ Ca(OH)_2 + 6\ H_2O \rightarrow 3\ CaO\ .\ Al_2O_3\ .\ 6H_2O + 3\ H_2$

foaming gas

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AAC manufacture

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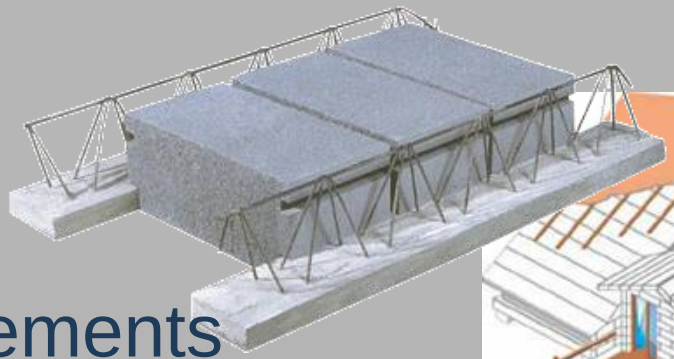
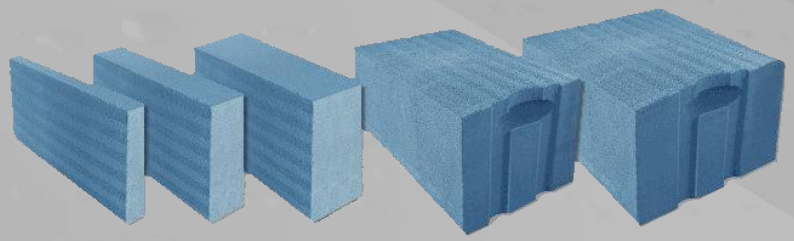
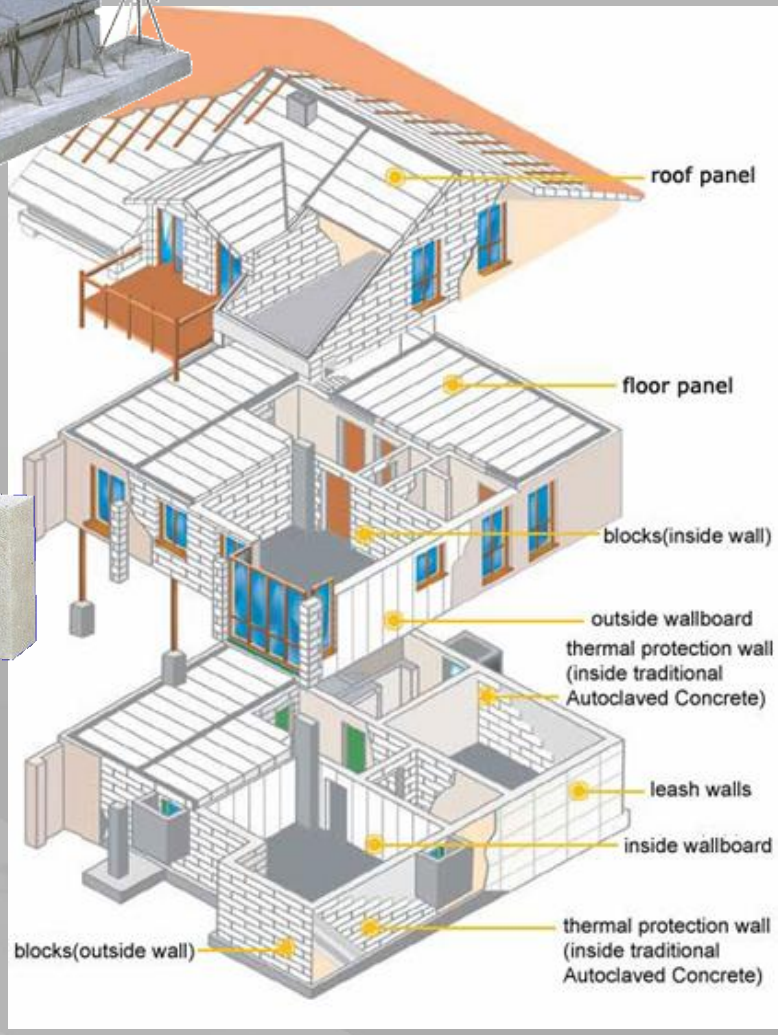
AAC - products

- blocks
- lintels
- ceiling elements
- panels
  - walls
  - partitions
  - floors
- chimney elements







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AAC - properties

- **compression strength classification:**
  - 1,5; 2; 2,5; 3; 3,5; 4; 4,5; 5; 6; 7 (MPa)
- **bulk density classification:**
  - 300 (250 –300); 350; 400; 450; 500; 550;..... 950; 1000 (kg/m^3)
- **λ = 0,11 – 0,17 W.m^{-1}.K^{-1}**
- **water absorptivity ≅ 15 %**

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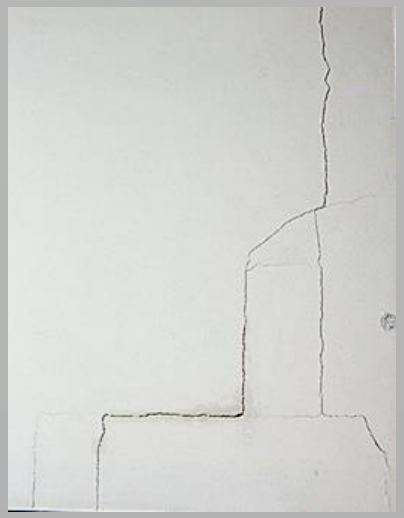
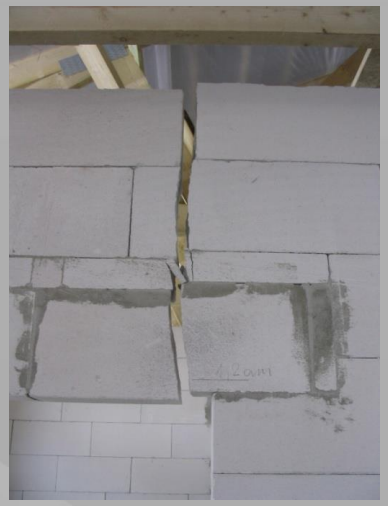
AAC - advantages

+ less amount of mortar
+ good thermal efficiency
+ easy sawing and cutting
+ light weight
+ easy rendering
+ price

AAC - disadvantages

- high expedition moisture
- long drying
- lower compressive strength
- creeping (cracks)
- volume changes with moisture





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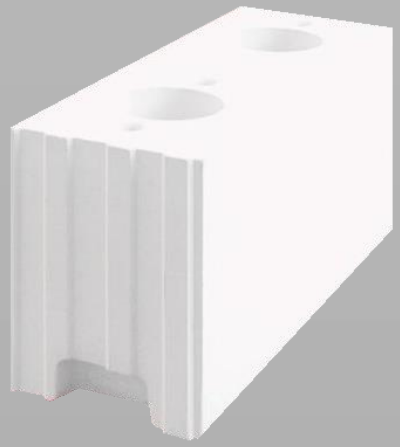
Autoclaved products

Sand lime masonry elements



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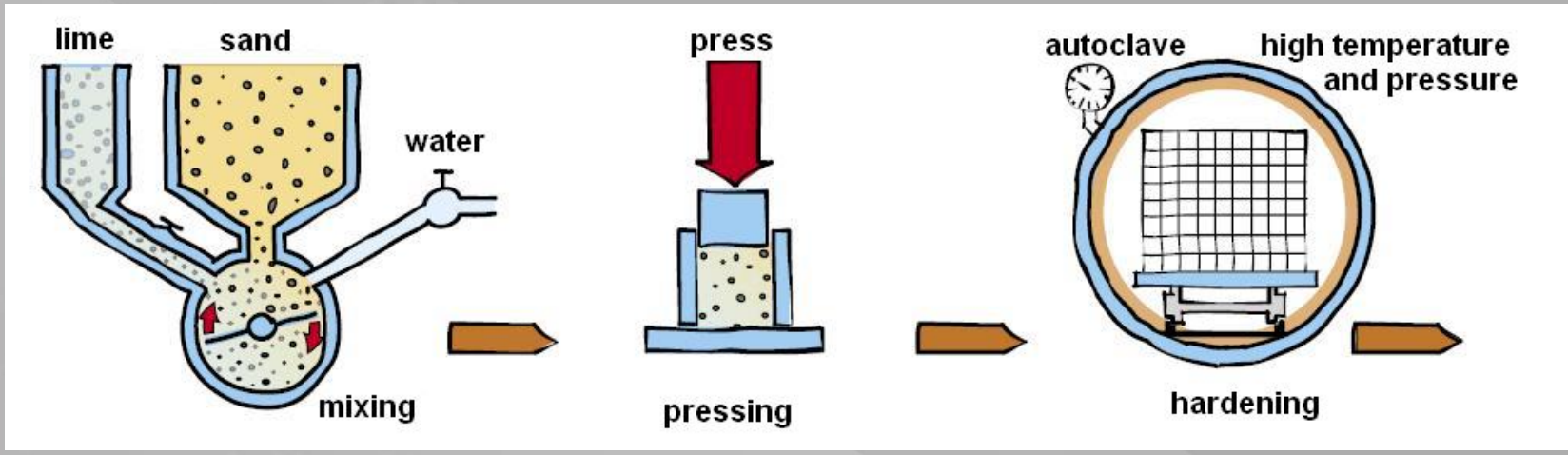
Sand lime masonry elements

- quicklime
  1 : 10 - 12
- sand
- water
- pigments



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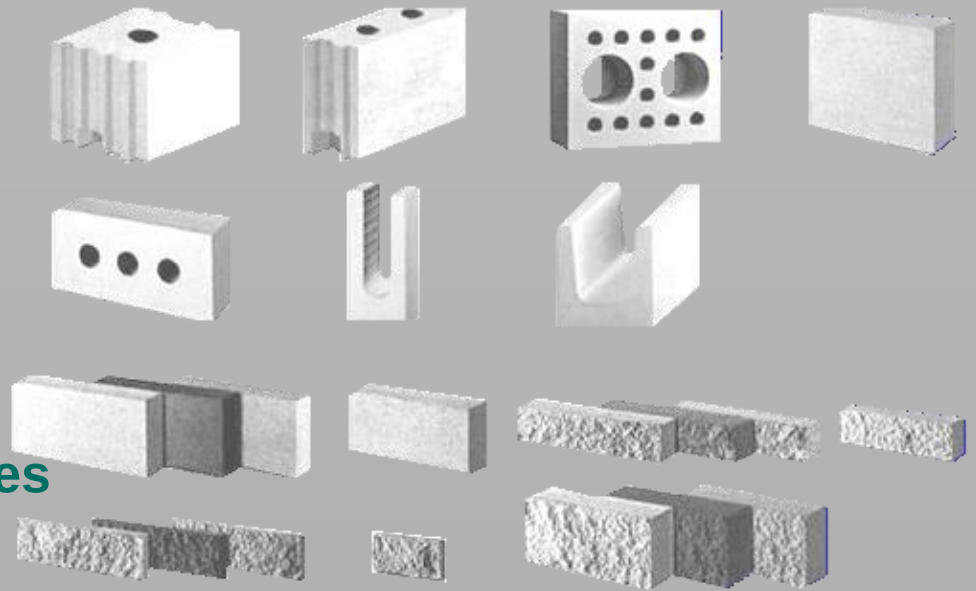
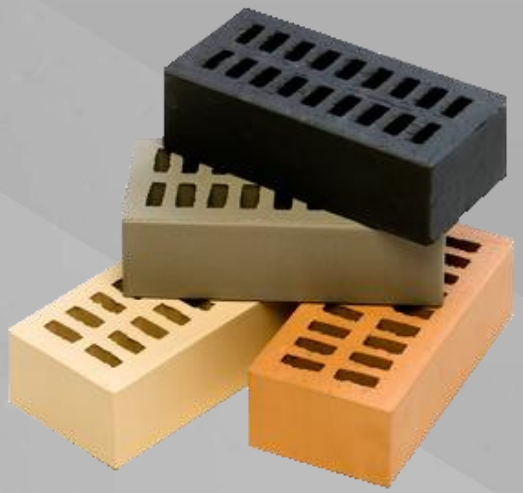
Sand lime masonry elements

- under the action of the high-pressure steam the lime attacks the particles of sand, and a chemical compound of water, lime and silica is produced which forms a strong bond of calcium silicate hydrates with the particles of sand
- **compressive strength**
  R_c = 15 - 40 MPa
- **good frost resistance**
- **ρ_v = 1300 – 2000 kg.m^{-3}**
- **λ = 0,9 W.m^{-1}.K^{-1}**

Sand lime masonry elements

- bricks
- blocks
  - full or hollow
  - smooth sides or interlocking grooves
- wall tiles
- lintels





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Sand lime masonry elements - advantages

+ high dimensional accuracy
+ smooth surface
+ good frost resistance
+ good fire resistance
+ rendering is not necessary
+ good resistence against chemicals
+ labor saving
+ good thermal accumulation

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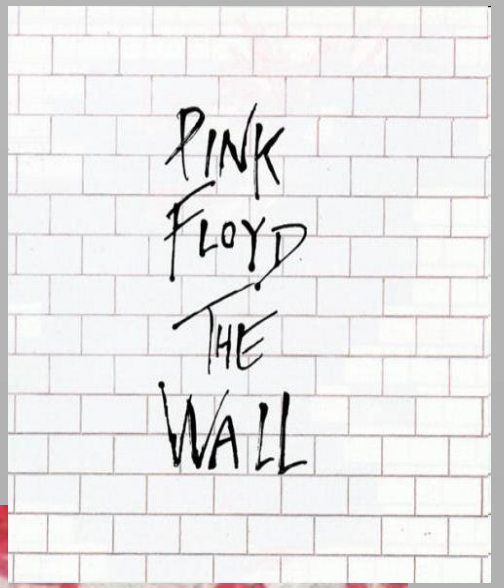
Sand lime masonry elements - disadvantages

- price
- efflorescence
- higher thermal conductivity
- difficult removal of graffiti



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Autoclaved products

Fibre cement

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Fibre cement

Components:

- **cement**
- **formerly asbestos fibers (**Eternit)
  - prohibited (health risk)

now:

- **cellulose fibers**
- **syntetic fibers (PVA)**
- **water**
- **sand** or microfillers
- additives (pigments)

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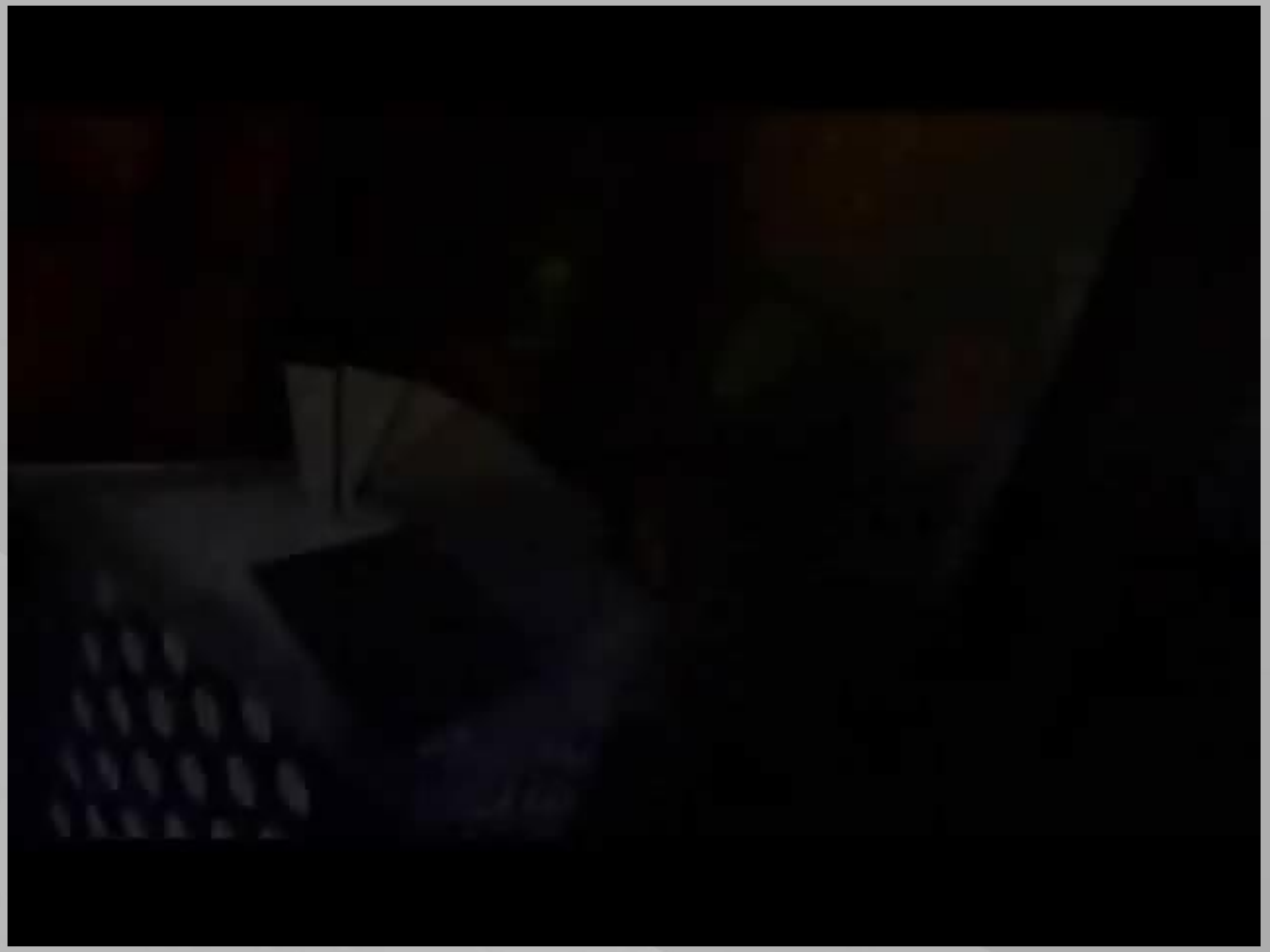
Fibre cement manufacture



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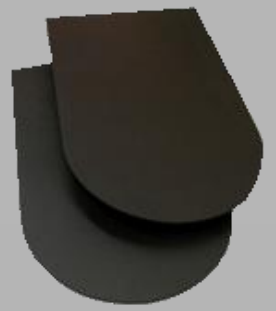
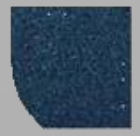
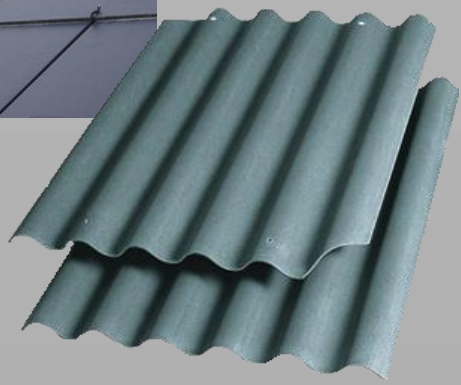
Fibre cement products

- **roofing**
  - **slates**
  - **corrugated sheets**







- **cladding**
  - **internal** (fire protection, partition walls, ceilings)
  - **external** (siding)

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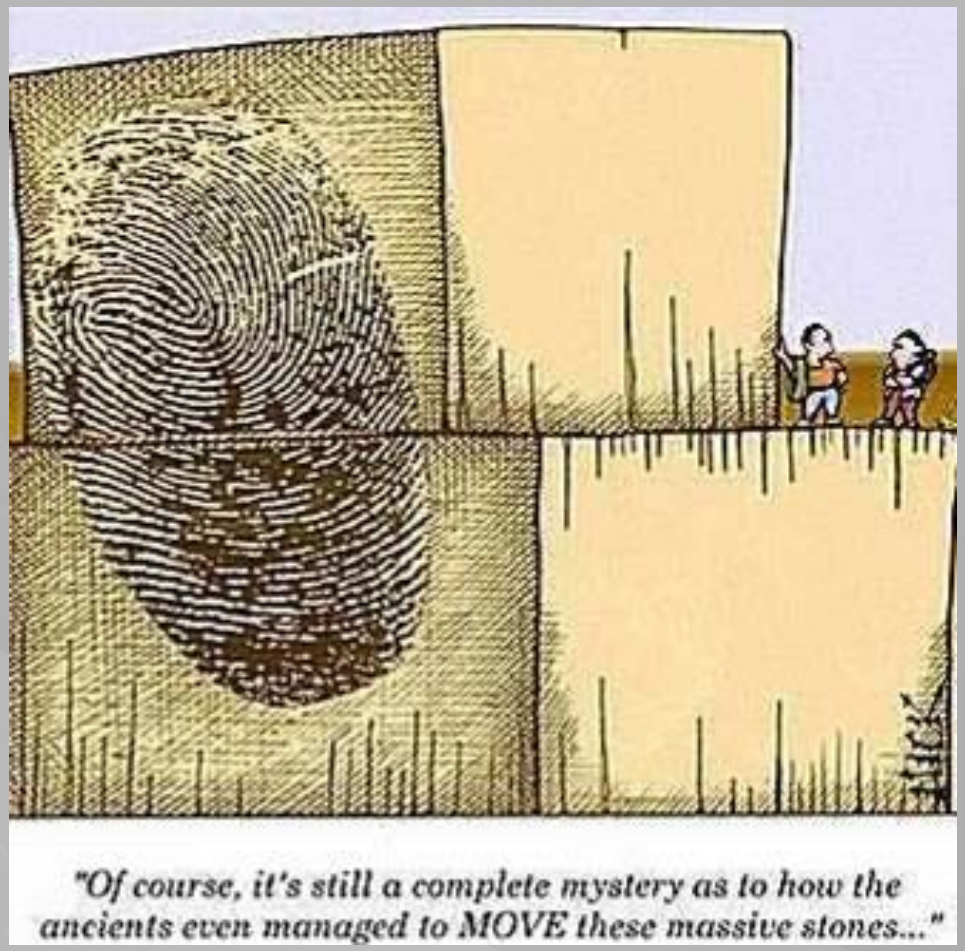
Building stone



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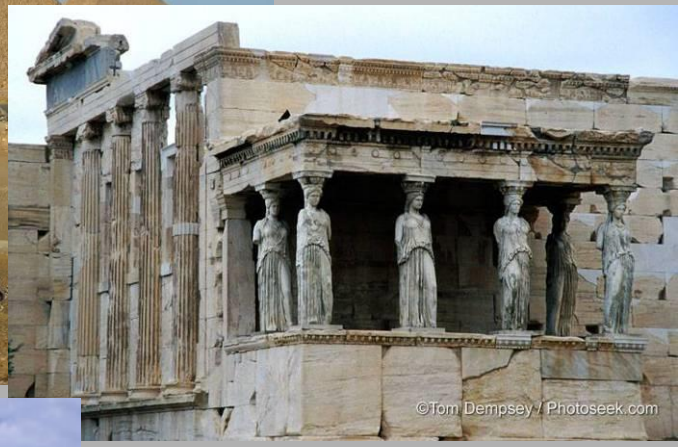
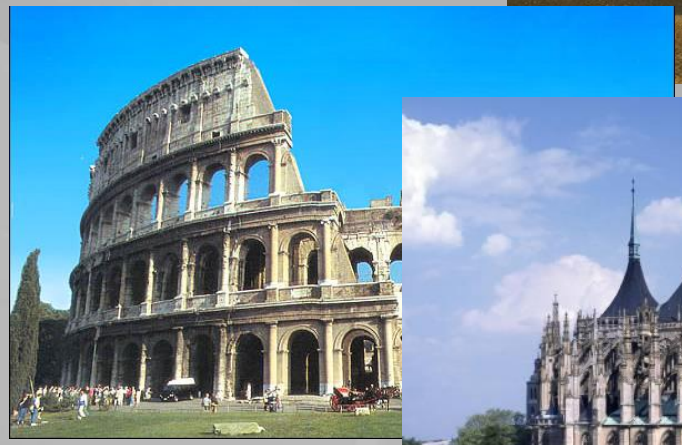
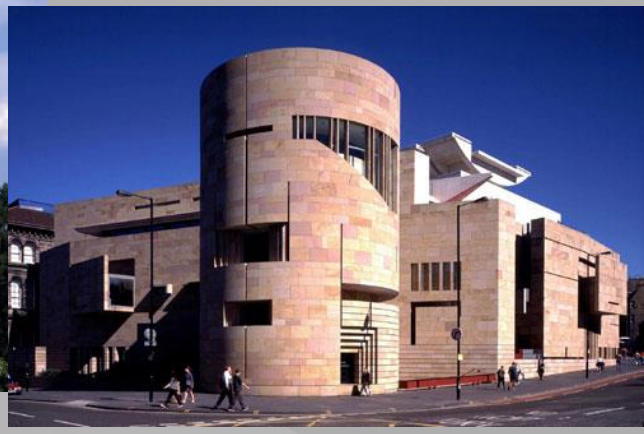
Building stone







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Building stone

- **all kinds of solid rocks, which have suitable properties to be used in construction works**
- rocks must have certain physical and chemical properties based on their mineralogical and petrographic composition, structure, texture, secondary alterations, etc.

dimension stones > 125 mm

(x aggregates < 125 mm)

Some properties of common rocks

Type of rock	Porosity (%)	Density pcf (kg/m^3)	Compressive strength ksi (MPa)	Modulus of elasticity ksi (MPa) $\times 10^{-3}$
Granite	0–2	165 (2650)	15–35 (103–241)	6–10 (41.3–68.9)
Limestone	0.5–30	168 (2700)	5–35 (34.4–241)	4–14 (27.6–96.5)
Marble	0–1.5	175 (2750)	10–30 (68.9–206.7)	4–14 (27.6–96.5)
Sandstone	1–20	160 (2580)	7–30 (48.2–206.7)	1–7.5 (6.9–51.7)
Slate	—	170 (2740)	—	—
Shale	2–30	140 (2255)	—	—

- **igneous**
  - R_c= 120- 400 MPa, ρ_v= 2500 – 3000 kg.m^{-3}
- **sedimentary**
  - R_c= 50 – 150 MPa, ρ_v= 2000 – 2800 kg.m^{-3}

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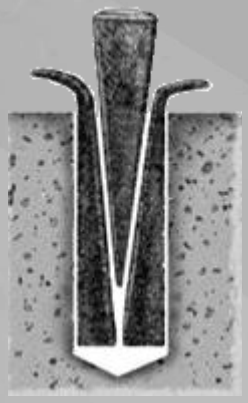
Stone extracting

- **quarry**
  - **broaching** (channeling)
    - holes, wedges
  - **blasting**
    - explosives



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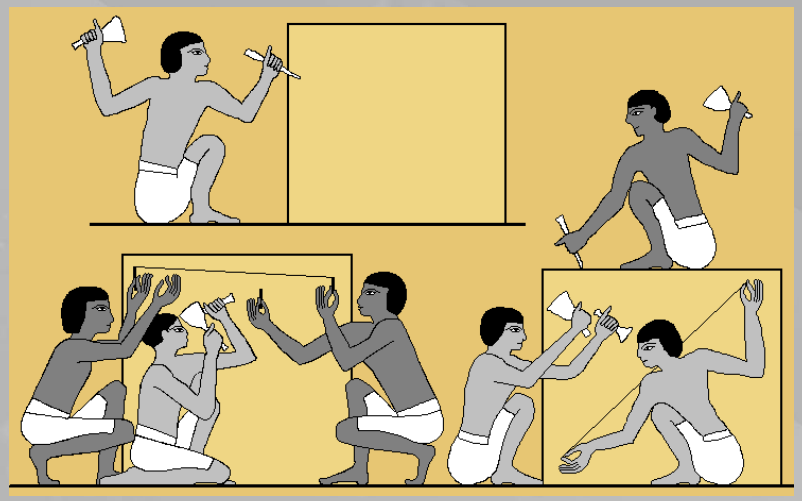
Stoneworking

- cutting
- carving
- surface finishing



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Granit processing

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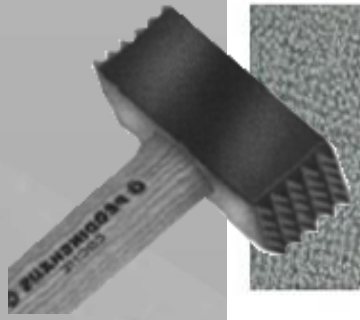
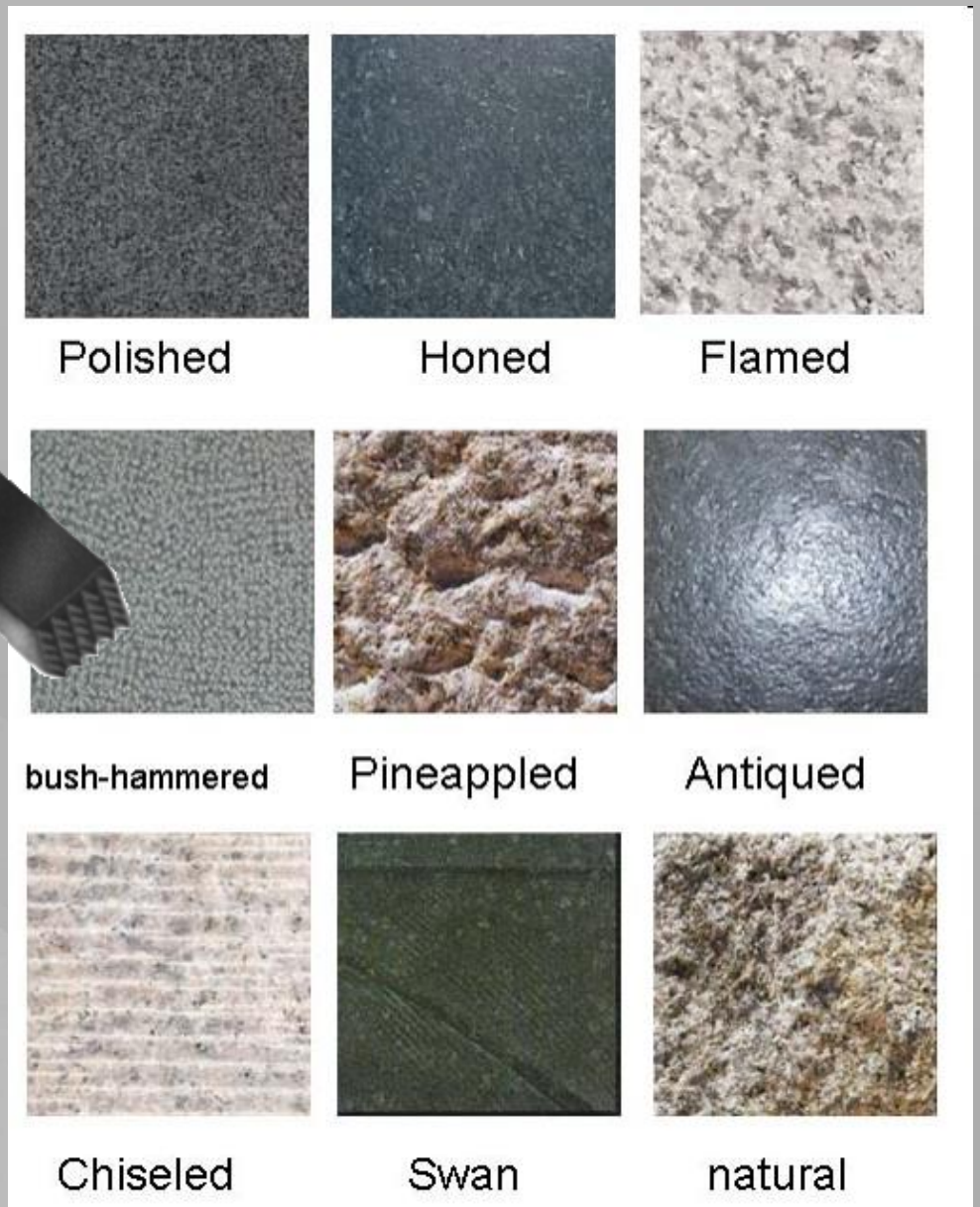
Surface finishes





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Granite

Mechanical properties:

- high compressive strength
- hard surface
- difficult to work with
- can be polished

Appearance:

- medium to coarse texture
- pink to dark gray or even black
- small porosity

Use:

- external walls, flooring tiles, kerbs, paving stones, stairs

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Basalt

Mechanical properties:

- high compressive strength
- very hard surface
- difficult to work with

Appearance:

- fine grained
- black, dark gray, greenish black

Use:

- external walls, floors, cobblestones
- aggregates
- products from melted basalt

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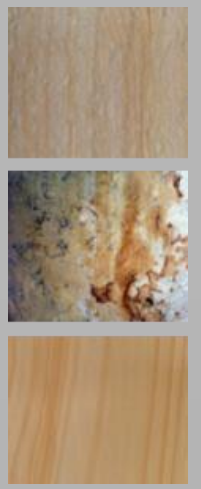
Sandstone



Mechanical properties:

- easy to work with
- only particularly resistant to weather

Appearance:

- sand grains (0.05-2mm) cemented together
- the color varies from red, green, **yellow**, gray and white

Use:

- decorative stones, flooring, paving, garden architecture

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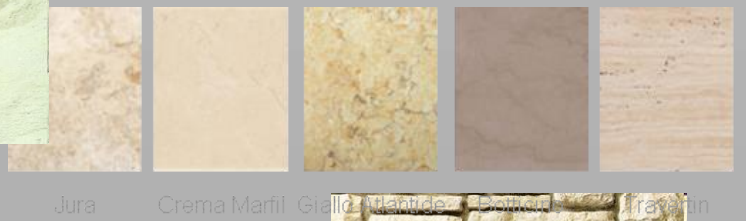
Limestone

Mechanical properties:

- easy to work with
- soft
- acid sensitive
- low porosity

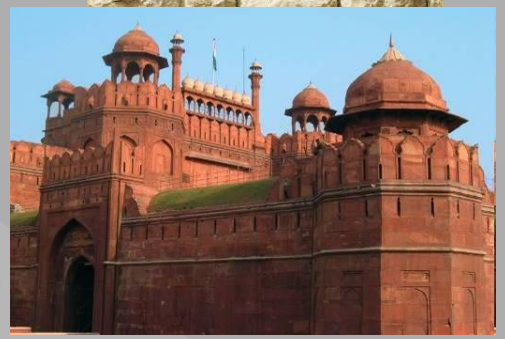
Appearance:

- often a sandy color, sometimes gray, greenish, or blackish



Use:

- flooring, wall cladding
- raw material for cement, lime…



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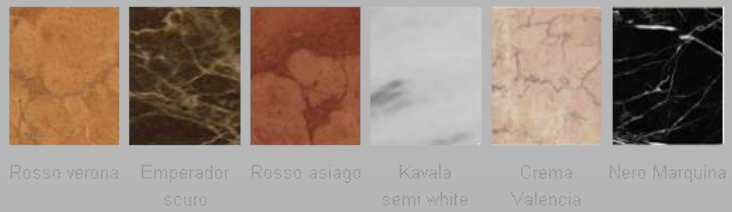
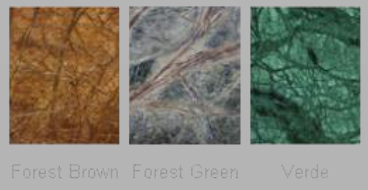
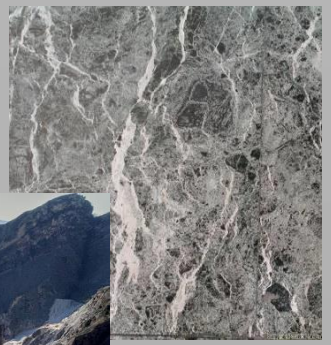
Marble (recrystallized limestone)





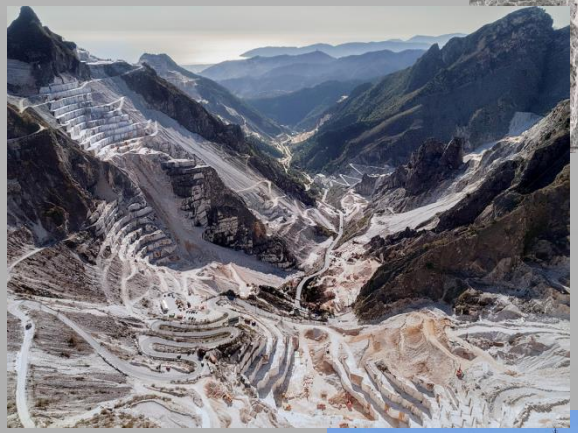


Mechanical properties:

- easy to work with
- easy to polish
- not resistant to acids

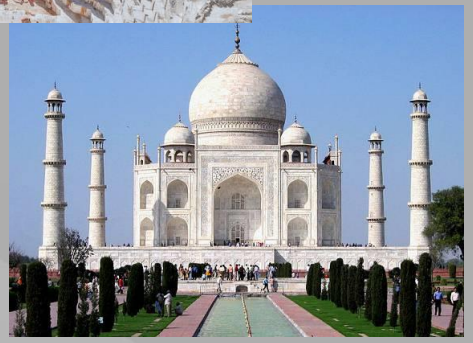
Appearance:

- a wide variety of colors



Use:

- interior decoration, statues
- cladding, floors (interior)



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Slate

Mechanical properties:

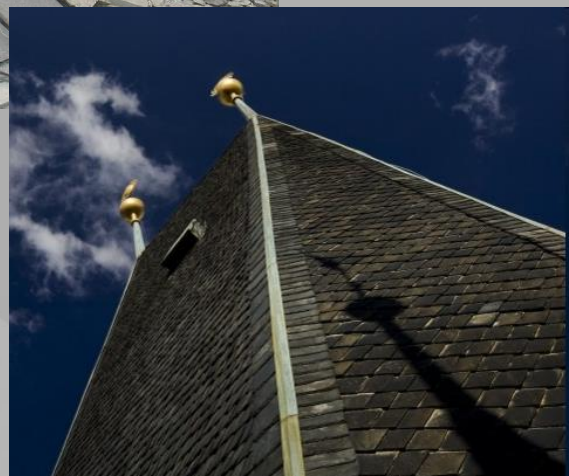
- can be split into thin layers
- extremely low water absorption
- good weather resistance

Appearance:

- color mostly gray

Use:

- cladding, flooring - tiles
- roof tiles - slates



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Dimension stone types

- **natural stone or rock that has been selected and fabricated** (trimmed, cut, drilled, ground) **to specific sizes or shapes**

- **quarried (ruble) stone**
- **dressed stone**
  - rough stone that has to be adjusted to fit a shape
- **cut stone**

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Rubble stone

- broken stone, of irregular size, shape and texture
- scrap left over from quarrying and processing
- may be roughly shaped into blocks, but it is not finished
- rubble stone walls
- fill
- stepping stones
- cyclopean masonry

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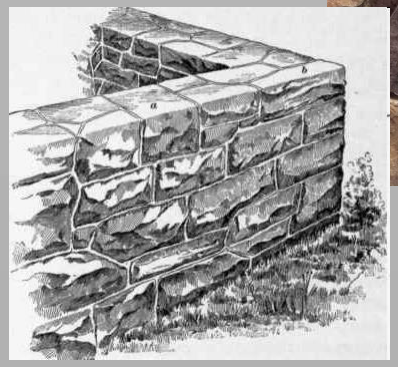
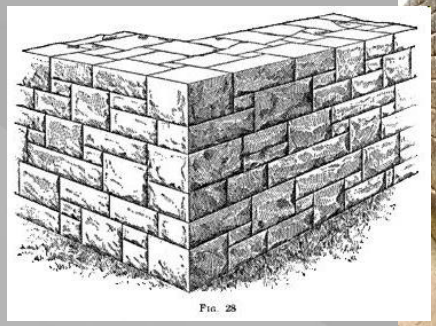
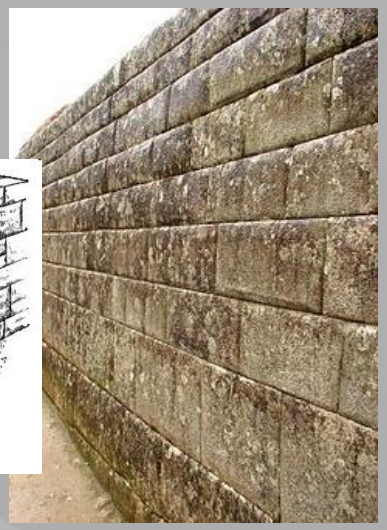
Stonemasonry

- **rubble masonry**
  - roughly dressed stones are laid in a mortar
  - quarried stone should be used



- **ashlar masonry**
  - stone masonry using dressed (cut) stones
  - ashlar blocks
  - small ashlar





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Stonemasonry

- **stone veneer**
  - protective and decorative covering of walls
  - relatively small thickness and weight
- **slipform stonemasonry**
  - a reinforced concrete wall with stone facing in which stones and mortar are built up in courses within reusable slipforms

Another building stone types

- kerbs
- paving stones
  - cubes, cobblestones
- stone cladding
- stairs

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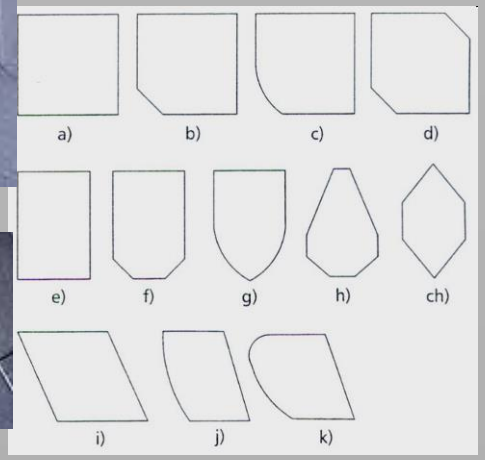
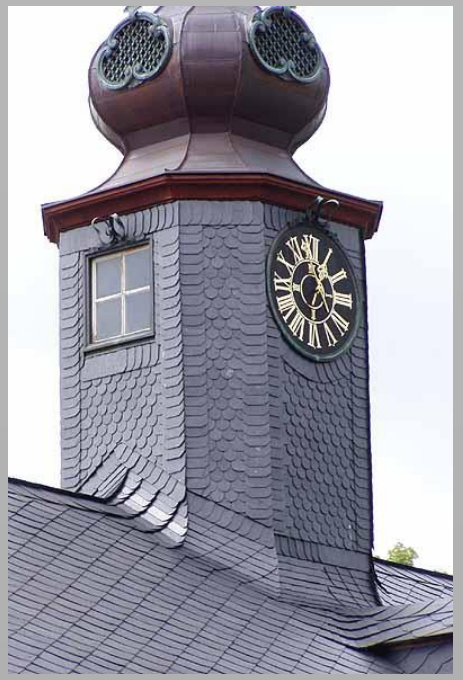
Stone roofing

- slate





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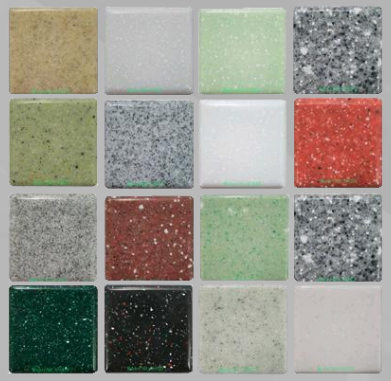
Artificial stone

- **binder** (white and/or grey cements or polymer resin), manufactured or natural **sands**, carefully selected **crushed stone** or well graded natural gravels and mineral coloring **pigments**
- manufactured s., cast stone, engineered stone



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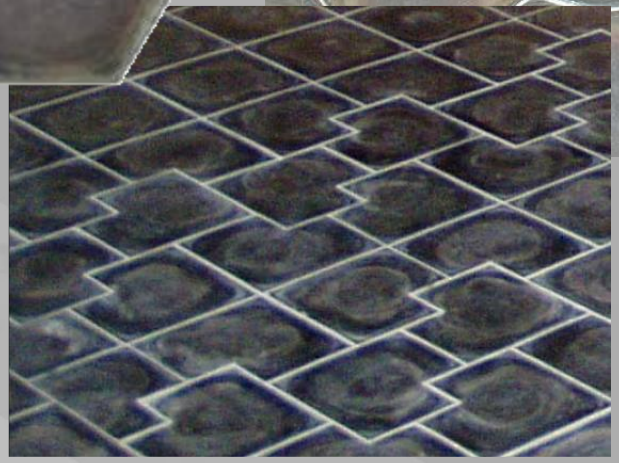
Cast basalt

- compressive strength 300 - 450 MPa
- hardness 8 (Mohs)
- outstanding wear and weather resistance



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Mineral fibers

EN 13162 – insulation material having a woolly consistency, manufactured from molten rock, slag or glass

- **boards or slabs** (λ= 0,035 - 0,045 W.m^{-1}.K^{-1}, ρ_V = 35 – 220 kg.m^{-3})
- **rolls** ($\lambda \cong$ 0,04 W.m^{-1}.K^{-1}, ρ_V= 70 kg.m^{-3})
- **batts, mats** ($\lambda \cong$ 0,04 W.m^{-1}.K^{-1}, ρ_V= 100-120 kg.m^{-3})
- **free wool**

Use:

- **thermal insulations**
- **acoustic insulations**
- **fire proofing**

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Asbestos

- **silicate minerals** (serpentine, amphibole, chrysotile, crocidolite) with long, (1:20) thin fibrous crystals
- fire resistant, strong, elastic
- **asbestos cement** (roofing, boards, pipes)
- **plasters, paints, sealants**

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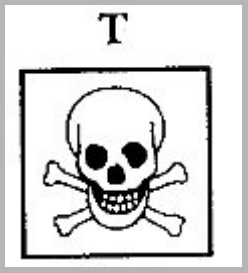
Asbestos



- prolonged inhalation of asbestos fibers can cause serious illnesses, (cancer - mesothelioma, asbestosis)

→ banned in EU

→ **difficult liquidation!**

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Building materials

Clay

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Earth constructions

Traditional constructions:

- rammed earth
- cob
- adobe
- half-timbered construction

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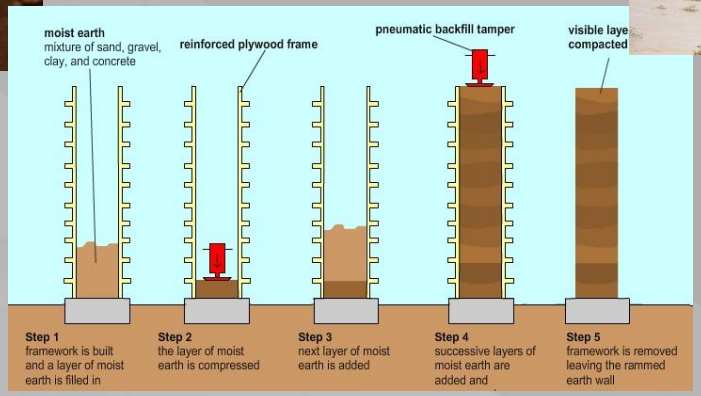
Earth constructions

Nowadays:

- pressed adobe (stabilization by cement, PP fibers)
- rammed earth



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Bentonite

- clay consisting mostly of very fine montmorillonite
- swells (expands) when wet (up to 700% of volume) – Na-bentonites
- high plasticity

+

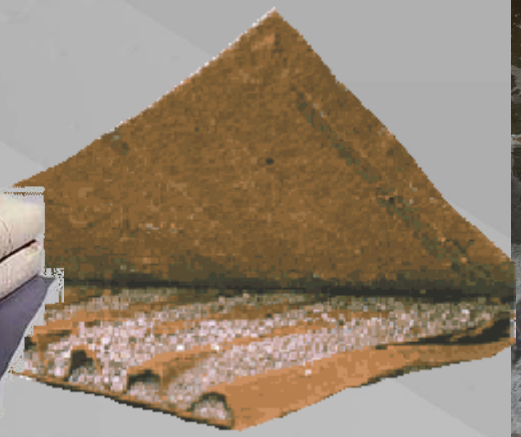
+ unlimited service life
+ self sealing

-

- price
- higher thickness
- have to be loaded

Bentonite - use

- **trenching, bored piling, and slurry wall installation**
- **waterproofing**
  - **panels**
  - **membranes**
  - **flexible strips** (sealing of concrete construction joints)



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Ceramic
(Burned clay)

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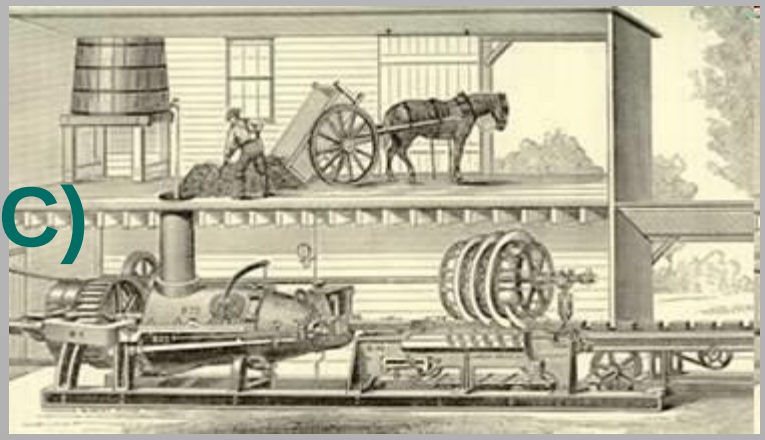
Ceramic manufacture



- **burning of ceramic mixture (900-1200 °C)**
- **raw materials:**
  - **clay minerals**
  - **sand,** cinder - reduction of shrinkage
  - **pore-forming agents** (sawdust, coal powder) – low bulk density bricks
  - **fluxes -** lower the maturing temperature and promote vitrification (feldspar)

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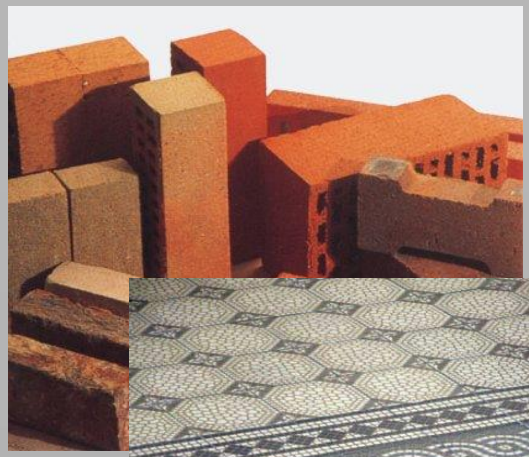
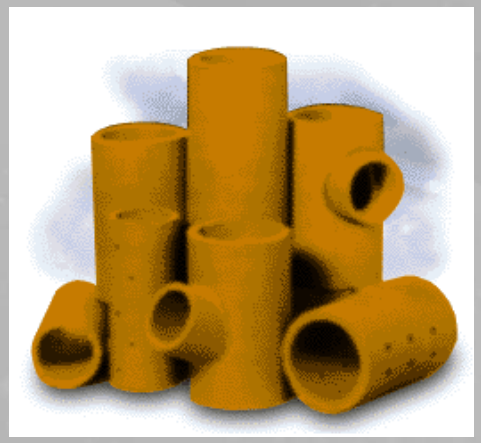
Ceramic manufacture

Building ceramic - products

- masonry units - bricks
- tiles
- stoneware
- sanitary products
- refractories





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Clay masonry units (bricks)

- a block, or a single unit of a ceramic material used in masonry construction, usually stacked together, or laid using various kinds of mortar to hold the bricks together and make a permanent structure

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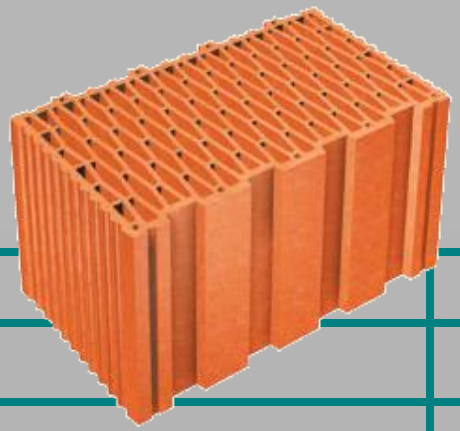
Ceramic body properties



Property	Unit	Value
density	$kg.m^{-3}$	2600-2700
bulk density (dry state)	$kg.m^{-3}$	1600-2200
gravimetric sorptivity	%	20-25
volume sorptivity	%	36-55
equilibrium moisture	%	2,0
modulus of elasticity	MPa	8000-12000
thermal conductivity	$W.m^{-1}.K^{-1}$	0,65-0,80
specific heat capacity	$kJ.kg^{-1}.K^{-1}$	0,9-1,1
thermal elongation coefficient	K^{-1}	$5,0.10^{-6}$
water vapor diffusion coefficient	s	$0,023.10^{-9}$
resistance to water vapor diffusion	-	5 až 10

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Freeze/thaw resistanc

Freeze/thaw resistance category according EN 771-1		Number of freeze/thaw cycles
F0	**passive exposure** (masonry in external walls if provided with suitable protection, masonry in internal walls)	0
F1	**moderate exposure** (protection to wall heads by roof overhangs or copings, damp proof courses at the top or base of walls)	15
		25
F2	**severe exposure** (unrendered masonry near to external ground level, unrendered parapets, unrendered external chimney masonry where saturation with freezing can occur)	50
		100

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Clay masonry unit - strength

EN 771-1: the mean compressive strength of a product must be declared by the manufacturer

- values given in national annexes

Czech N.A.

Strength class	Compressive strength MPa	
	mean	single
P 2	2	1,6
P 4	4	3,2
P 6	6	4,8
P 8	8	6,4
P 10	10	8,0
P 15	15	12,0
P 20	20	16,0
P 25	25	20,0
P 30	30	24,0
P 35	35	28,0
P 40	40	32,0

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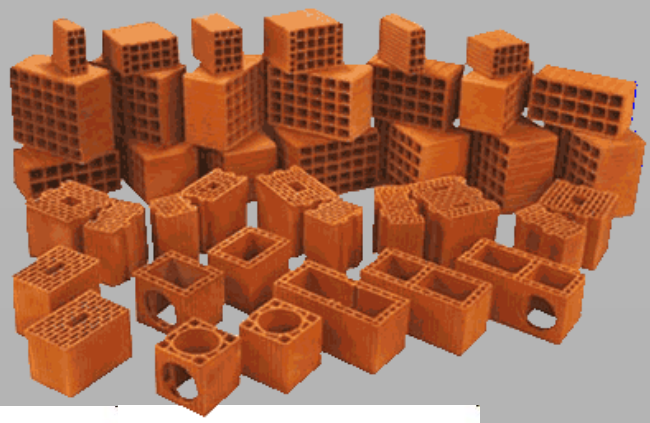
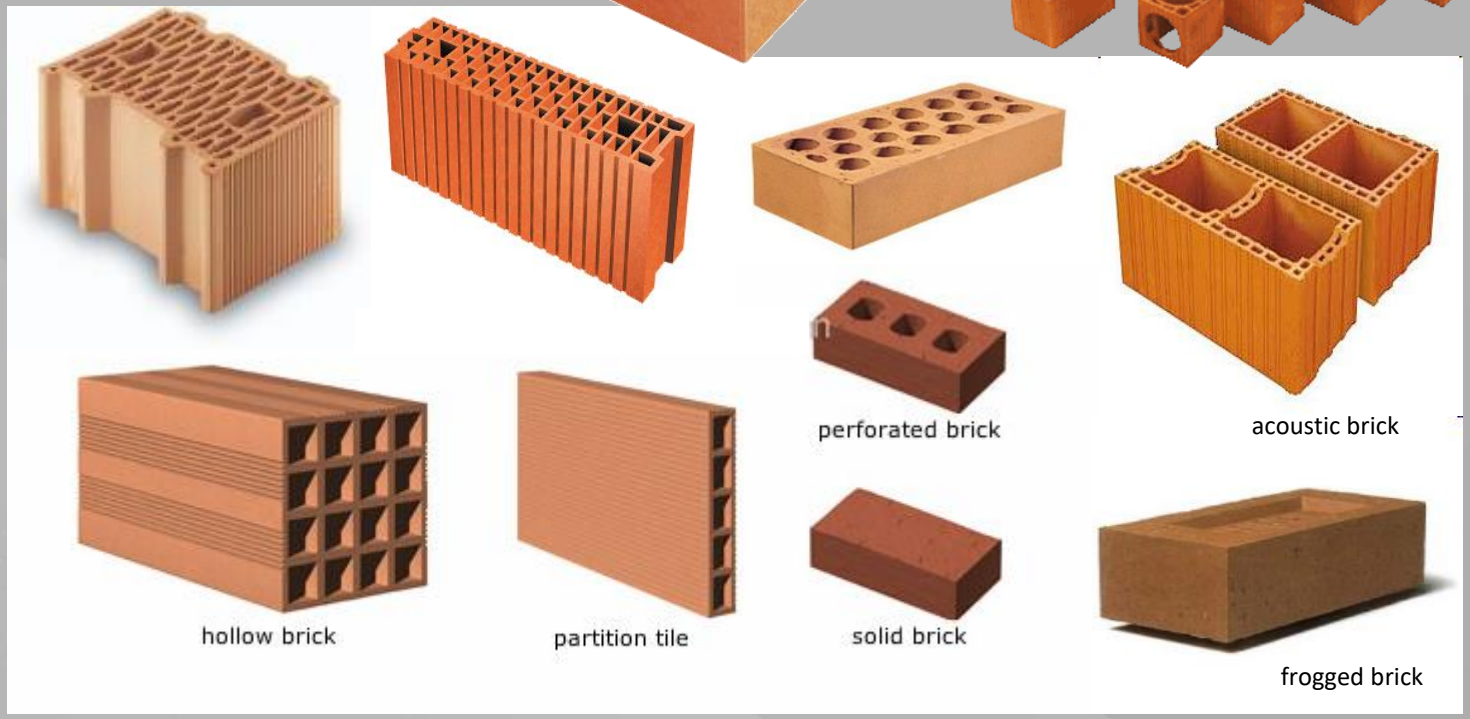
Ceramic masonry units types





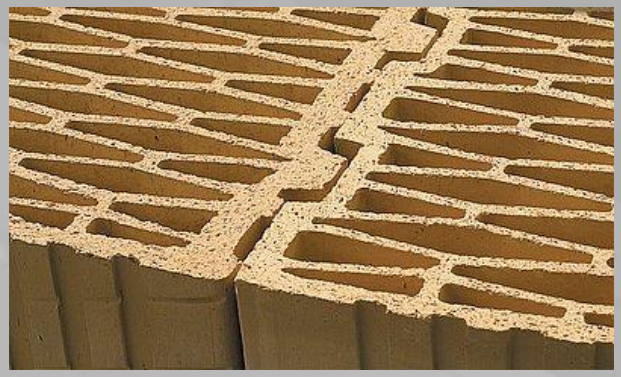
Masonry units – type Therm

– porosity 15 – 20%

– λ = 0,4 W.m^{-1}.K^{-1}

– ρ_v < 1450 kg.m^{-3}

– thermal insulating mortar



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Thermal insulation improving

- **filling of the cavities**
  - **perlite** (first layers)
  - **mineral wool**
  - **polystyrene** – loose, integrated

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Thermal insulation improving

- **PUR foam** instead of mortar for horizontal joints
  - better thermal insulation
  - possibility to work in the cold weather

?

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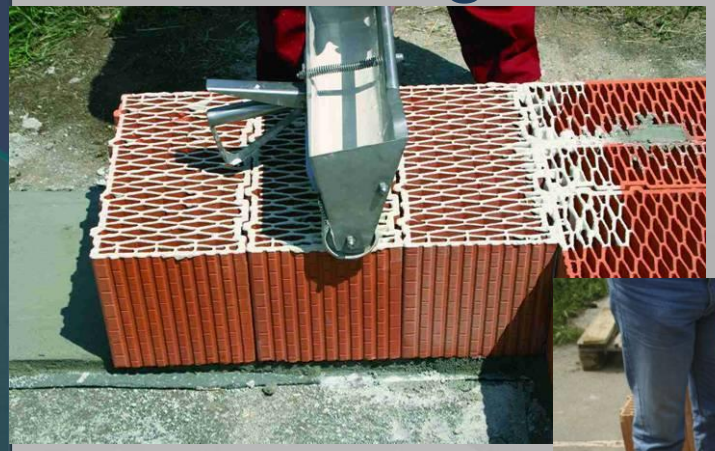
Grinded bricks

- brick are after burning grinded with accuracy 1 mm
- exact height – minimazing of mortar



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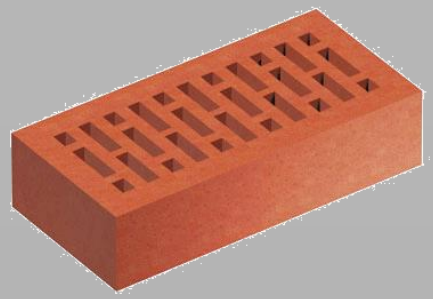
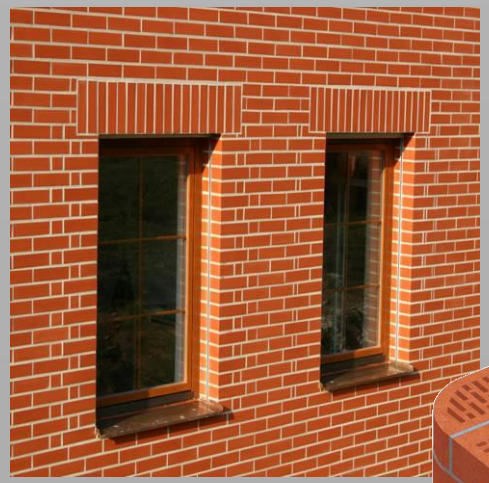
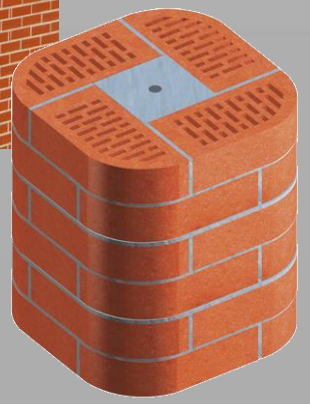
Clinker bricks

- partially vitrified brick
- burnt under temperatures so high that the pores of the fuel property are closed by the beginning sinter process
  - high resistance against weather
  - low porosity - minimal sorptivity
  - high frost resistance
  - high bulk density and strength
  - withoutt rendering







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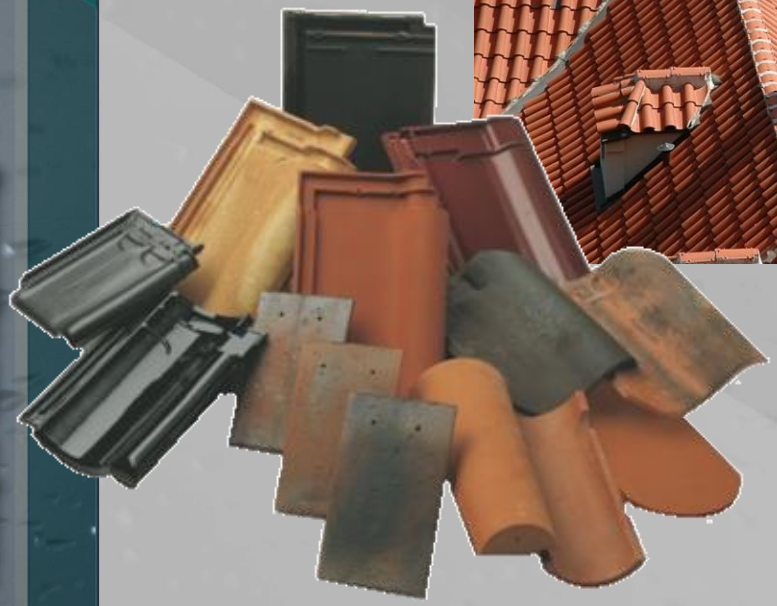
Clay roof tiles



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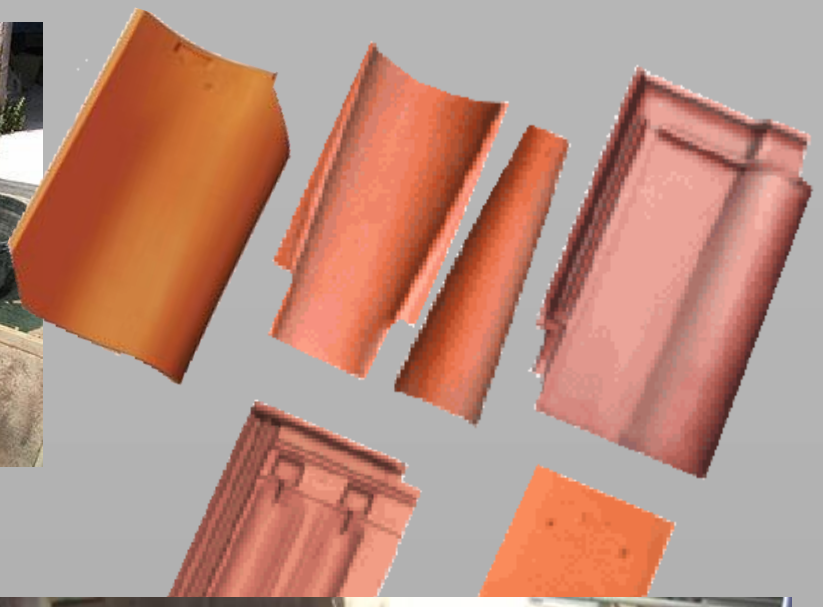
Clay roof tiles

- **shaping**
  - pressing
  - extruding
- **shape**
  - hollow tile
  - hollow interlocking tile
  - flat interlocking til
  - plain tile
- **surface**
  - natural red
  - engobed
  - glazed



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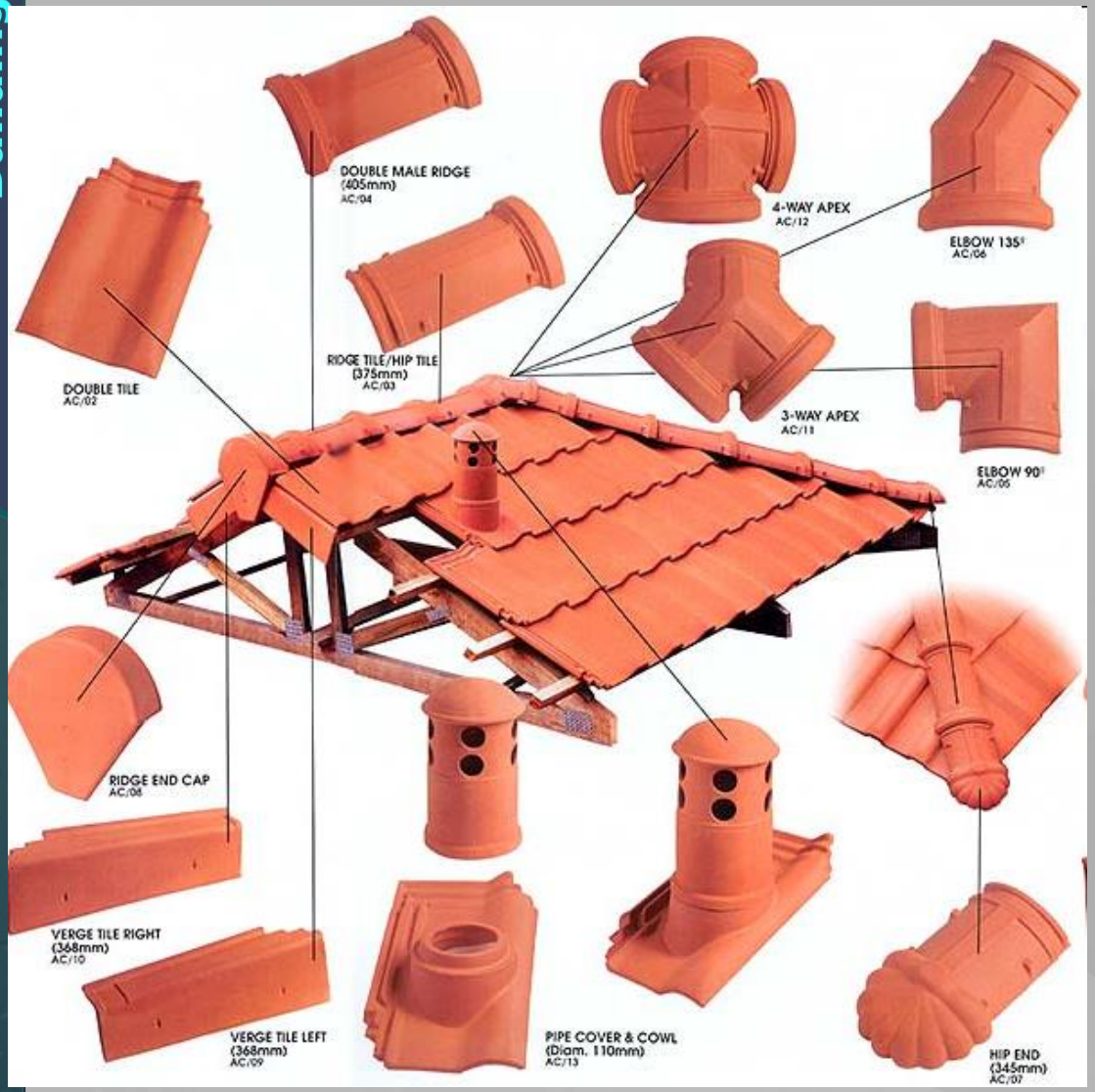
Accesorries



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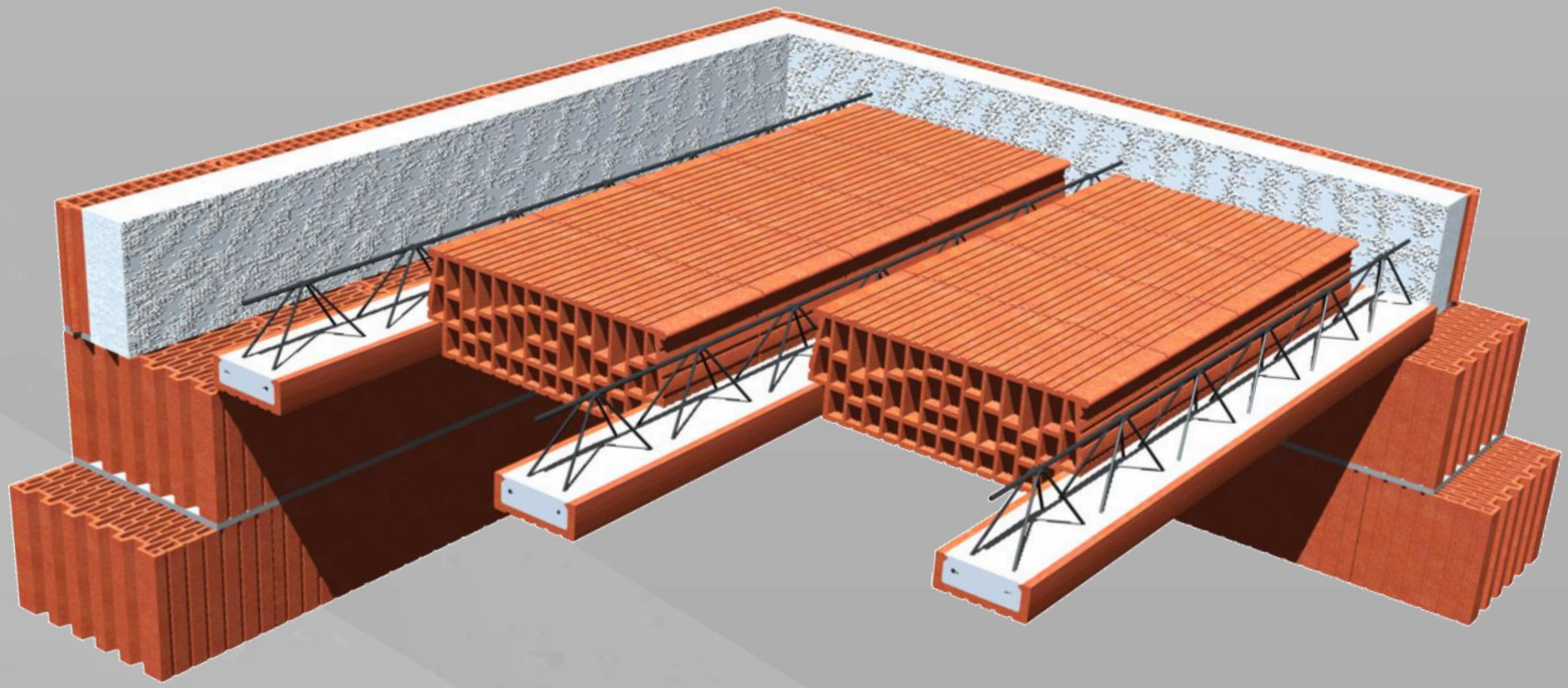
Ceramic ceilings



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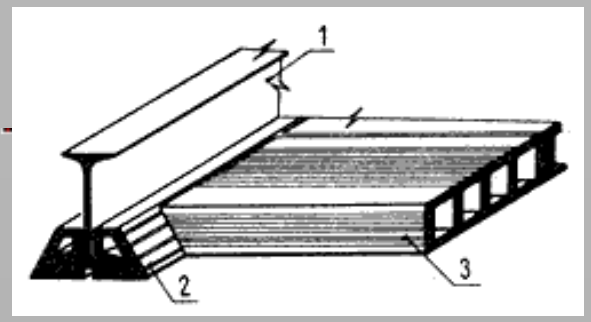
Ceramic ceilings

- **hollow brick floor slabs**



- **lintels**

- brick – concrete **ceiling beams**

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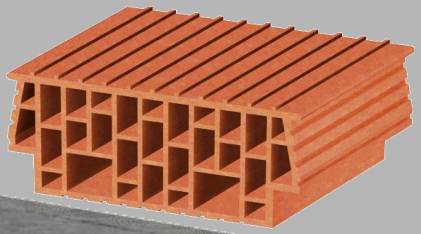
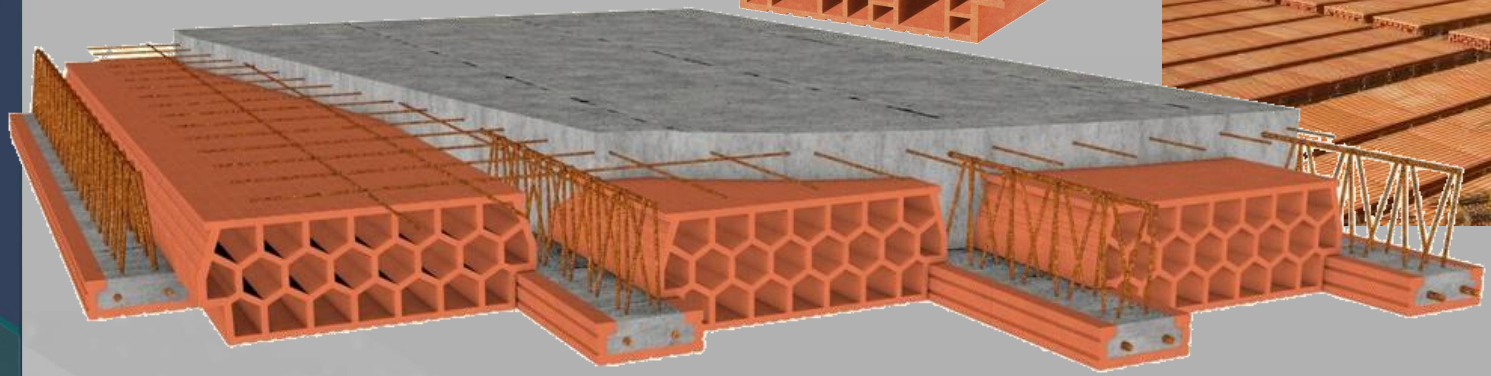
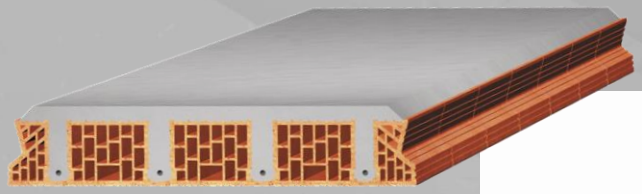
Ceramic ceilings

- hollow brick units





- floor/ceiling panels



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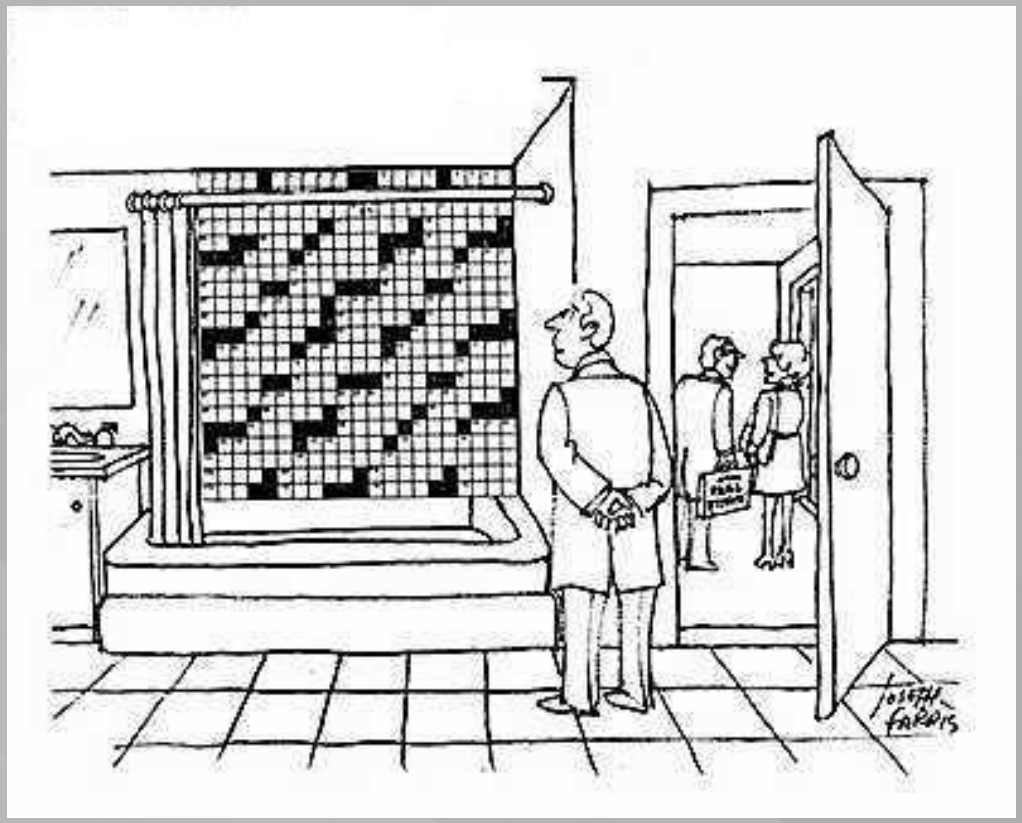
Ceramic tiles



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Ceramic tiles

- **EN 14411** : **slab made from days and/or other inorganic raw materials**
- **generally used as coverings for floors and walls**

Park Güell, Barcelona

Cafe Imperial, Prague

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Ceramic tiles

- **methods of manufacture**
  - **extruding** - shaped in the plastic state in an extruder, the column obtained being cut into tiles of pre-determined dimension
  - **dry-pressing** - file formed from a finely milled body mixture and shaped by pressing
- **surface**
  - **glazed,**
  - **engobed**
  - **unglazed**
  - **polished**

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Properties of ceramic tiles

- resistance to fire - incombustible
- unaffected by light
- water absorption E [% of water by mass]
  - low: **E ≤ 3 %**
  - medium: **3% < E ≤ 6%**
  - high: **E > 10%**
  - **porcelain tile** – fully vitrified tile, **E ≤ 0,5 %**
- resistance to abrasion
- frost resistance
- resistance to staining
- resistance to chemicals

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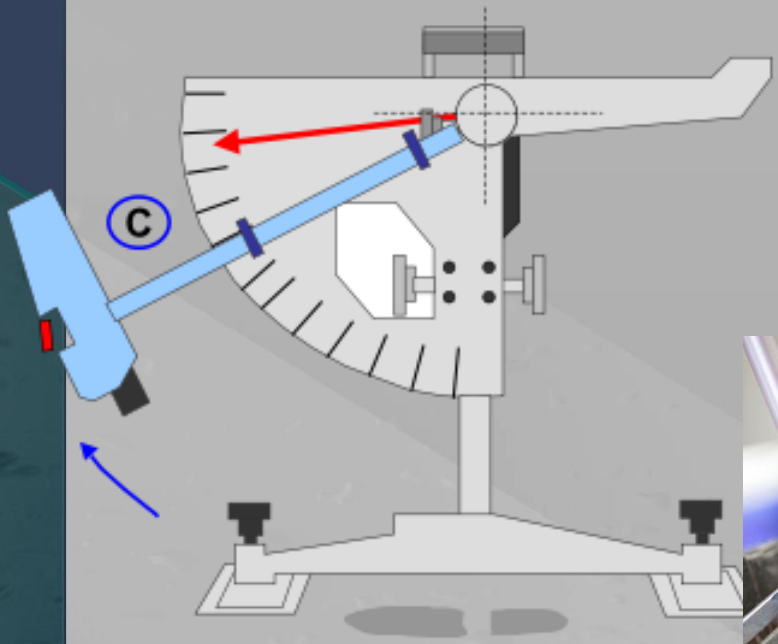
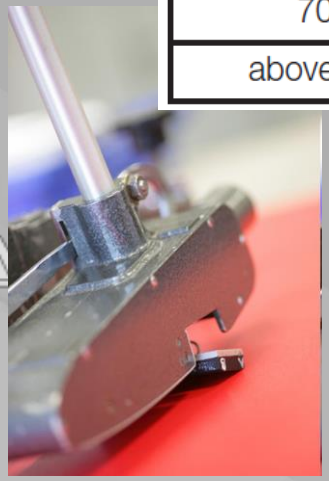
Sliperiness

- a pendulum coefficient of friction
- a surface microroughness





Minimum roughness (Rz)	Contaminant
20 µm	Clean water, coffee, soft drinks
45 µm	Soap solution, milk
60 µm	Cooking stock
70 µm	Motor oil, olive oil
above 70 µm	Gear oil, margarine

Pendulum numbers	Slip resistance
0 to 24	Dangerous
25 to 34	Marginal
35 to 64	Satisfactory
65 and above	Excellent

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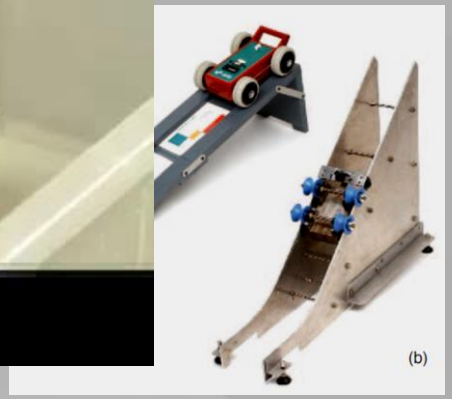
Slipperiness

- ramp test – slip resistance
- roller – coaster tests

CLASSIFICAZIONE *CLASSIFICATION*	ANGOLO D'INCLINAZIONE *INCLINATION CORNER*	PROVE SU "PIANO INCLINATO" *TEST ON "INCLINED PLANE"*
R 9	≥ 3° ; ≤ 10°	coefficiente d'attrito minimo *minimum iniction coefficient*
R 10	> 10° ; ≤ 19°	coefficiente d'attrito normale *normal iniction coefficient*
R 11	> 19° ; ≤ 27°	coefficiente d'attrito superiore alla norma *medium iniction coefficient*
[illegible]	> 27° ; ≤ 35°	coefficiente d'attrito elevato *high iniction coefficient*
[illegible]	> 35°	coefficiente d'attrito molto elevato *very high iniction coefficient*

Two bare-foot test persons are used to determine the acceptance angle, after the pedestrian surface material being tested has been continuously coated with water containing a wetting agent.



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Ceramic tiles choice

- **location** → absorptivity, frost resistance
- **type and intensity of stress** →
  abrasion resistance, slip resistance
- **esthetical solution** → size, color, surface

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Stoneware

- **a vitreous or semi-vitreous ceramic**
- though dense, impermeable and hard enough to resist scratching by a steel point, differs from porcelain because it is more opaque, and normally only partially vitrified

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Stoneware - properties

- color : grey or brownish
- usually glazed
- absorptivity: 0 – 4 %
- bending strength: 15 - 40 MPa
- very dense
- good weather resistance
- chemical resistance
- high abrasion resistance

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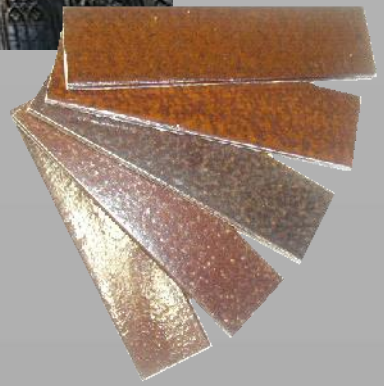
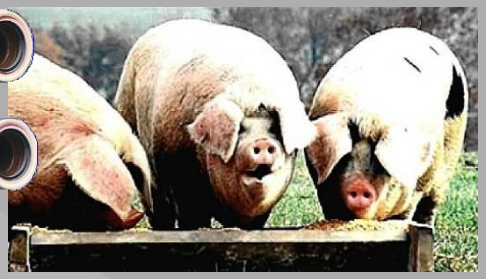
Stoneware

- floor and wall tiles
- roof tiles
- sewer pipes
- agricultural
- chemical
- garden
- chimney lining





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Sanitary ceramic

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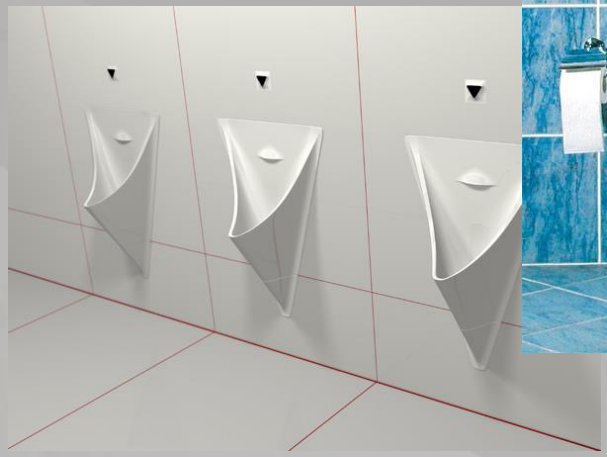
Sanitary ceramic

- **fireclay**
- **vitreous china**
- glazed
  - resistant to water absorption, burning, stains, scratching and attack by acids or alkalis
- basins
- toilets
- bidets
- urinals
- bathtubs



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Building materials

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Building materials

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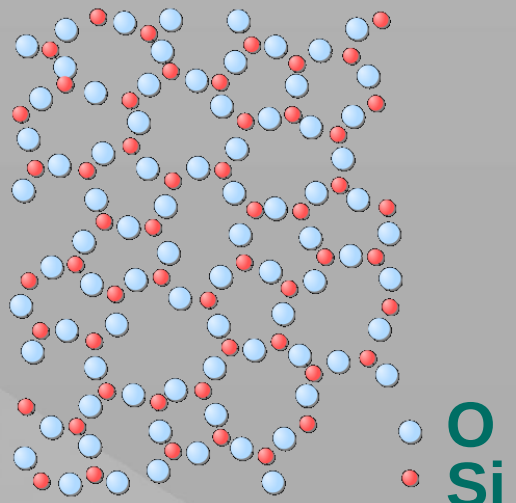
Glass

- amorphous
- composed of about 75% silica (SiO_2) + Na_2O, CaO + several minor additives
- homogenous
- transparent
- solid and hard
- brittle
- chemical resistant
- gas-tight



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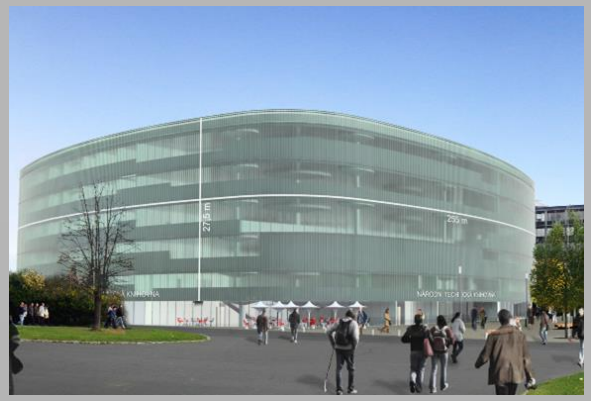
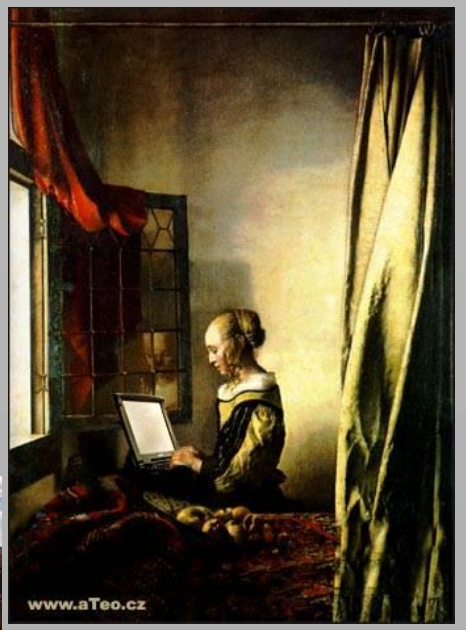
Glass in buildings

- glazing
- facades
- roof constructions
- partitions
- floors,stairs…





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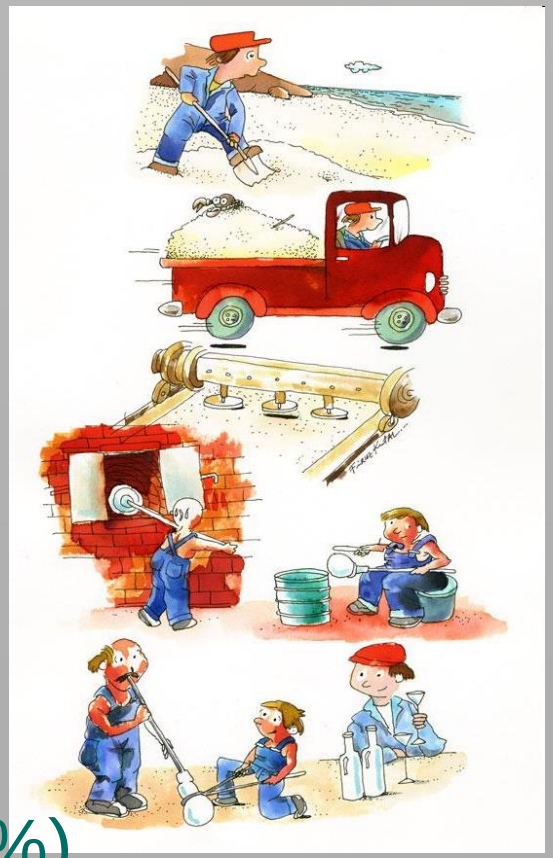
Glass manufacture

- **melting of components at 1400 - 1600°C**

Components:

- **sand** (60-80% SiO_2)
- **fluxes**
  - to lower the melting point (soda ash - Na_2CO_3)
  - to widen the range of workability (lime)
  - better chemical durability (MgO, Al_2O_3)
- **broken glass** - „cullet“ (to 30%)
  - to improve heat transfer during melting



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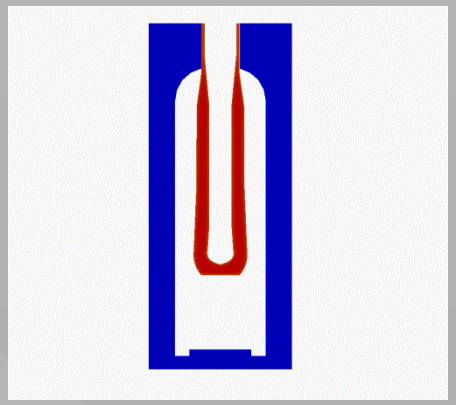
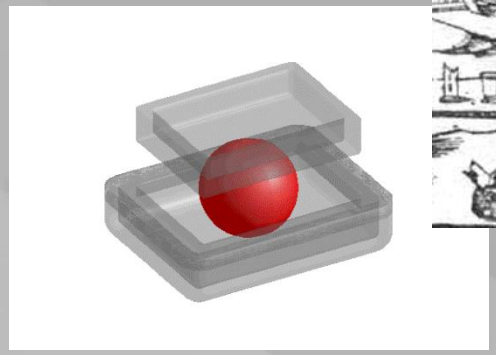
Glass shaping

- hollow glass
  - blowing
- blocks, roof tiles
  - molding
- flat glass
  - drawing
  - rolling
  - float
- fibers
  - extruding
  - spinning





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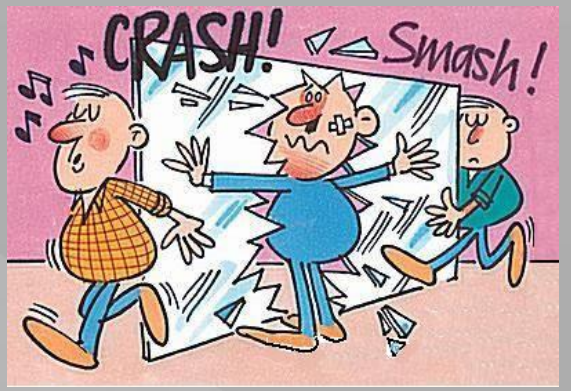
Glass properties

- can be influenced by composition

Common soda-lime glass:

- density: **2200 – 3600** kg.m^{-3}
  - lead glass: up to 6000 kg.m^{-3}
- compressive strength: **700 – 1200 MPa**
- bending strength: **30 – 90 MPa**
- Young's modulus: **50 – 90 GPa**
- λ = **0,6 – 0,9 W.m^{-1}.K^{-1}**
- hardness (Mohs) : **6 - 7**



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Glass properties

- **transparency**
  - depends on type and thickness (up to 92%)
  - differs for different wavelengths (UV x IR)
  - can be influenced by the coating by oxides
- **strength**
  - depends on surface quality (polishing)
  - tensile strength decreases with increasing thickness
  - toughening (heat, chemicals)
- **fragility**
  - high E and low tensile strength

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Glass products

- flat glass
- formed glass
- foamed glass
- fibers
- microspheres
- aerogel

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Flat glass - float proces





How is flat glass made?

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Flat glass – drawed, float

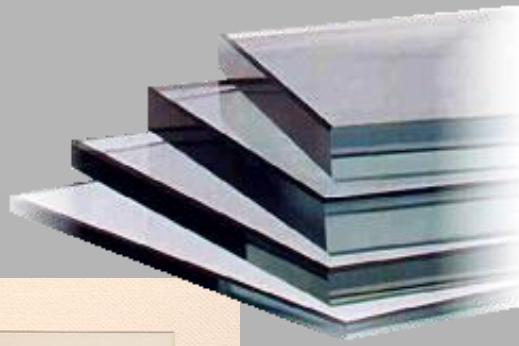
- **thickness 0,5 - 20 mm**

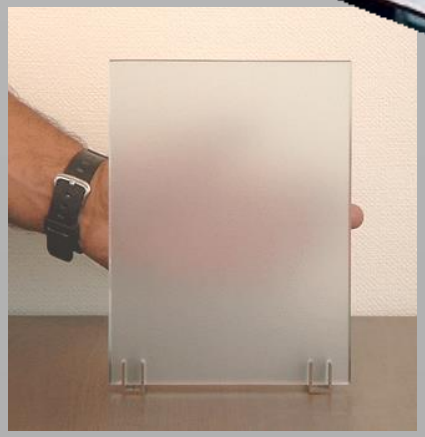
drawed glass – lower quality

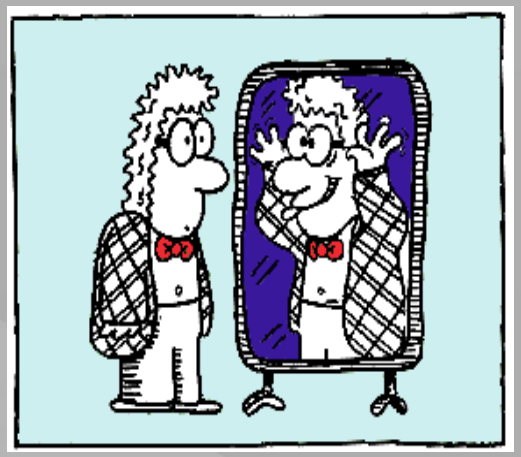
- frosted (by sand or acid)

float glass

- clear
- colored (metal oxides – Fe, Cu, Co, Ni, Ti)
- low E (= low emissivity) - reflects or absorbs IR light
- mirrored

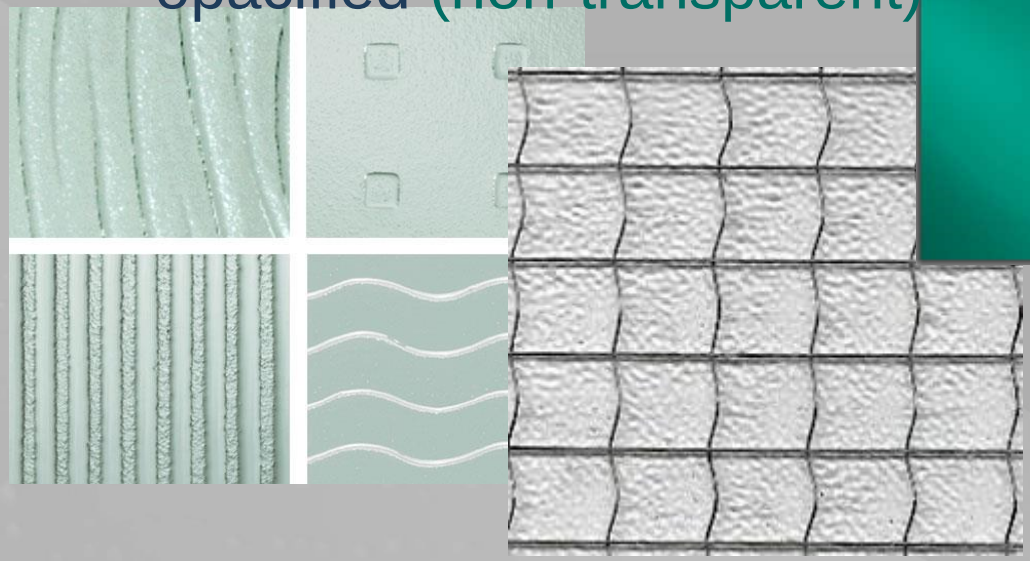






Rolled glass

- passing a stream of molten glass between two steel rollers
- **translucent** (transmission 75 - 88 %)
  - patterned
  - wired
  - opacified (non-transparent)



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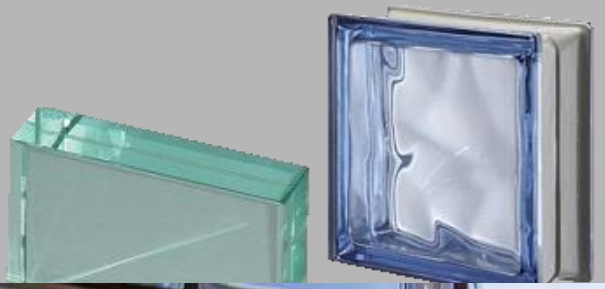
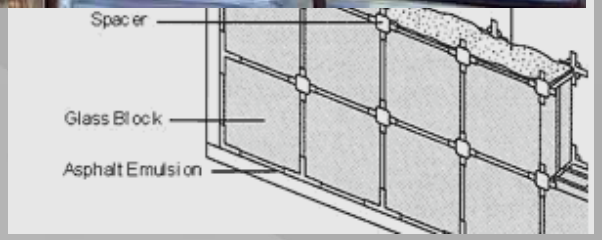
Glass building elements

- **hollow blocks**
  - mortar- glass system
- **full blocks**
- **U- profiles**
- **roof tiles**





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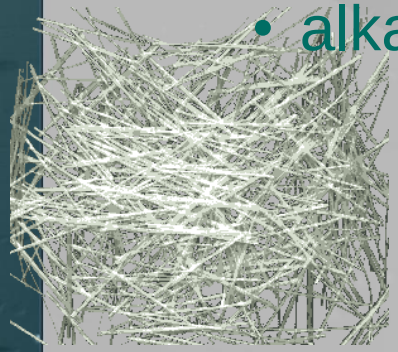
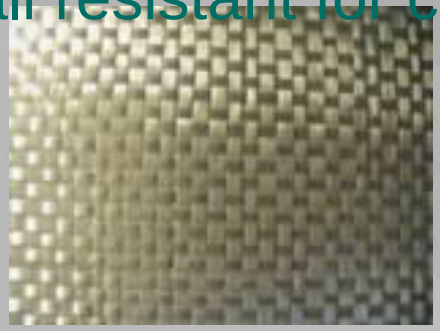
Glass fibers

- **long –** continuous filament process
  - – strands (rovings, woven cloth)
    - reinforcement of different materials, laminates - fiberglass
  - – choped
    - fiber-reinforced thermoplastic
    - alkali resistant for cement





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Mineral wool

- **glass woll** (sand)
- **rock wool** (basalt or sla

Use:

- thermal insulation
- acoustic insulation

\+ **nearly non-combustible** (resin binder)

\+ **very good water vapor difussion** (breaths)

\+ **noise reduction**

\- **high water absorptivity** (hydrofobization)

\- **health risk** (respirators)

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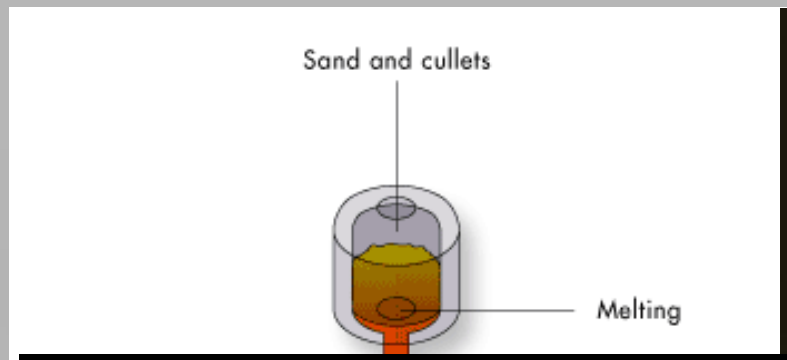
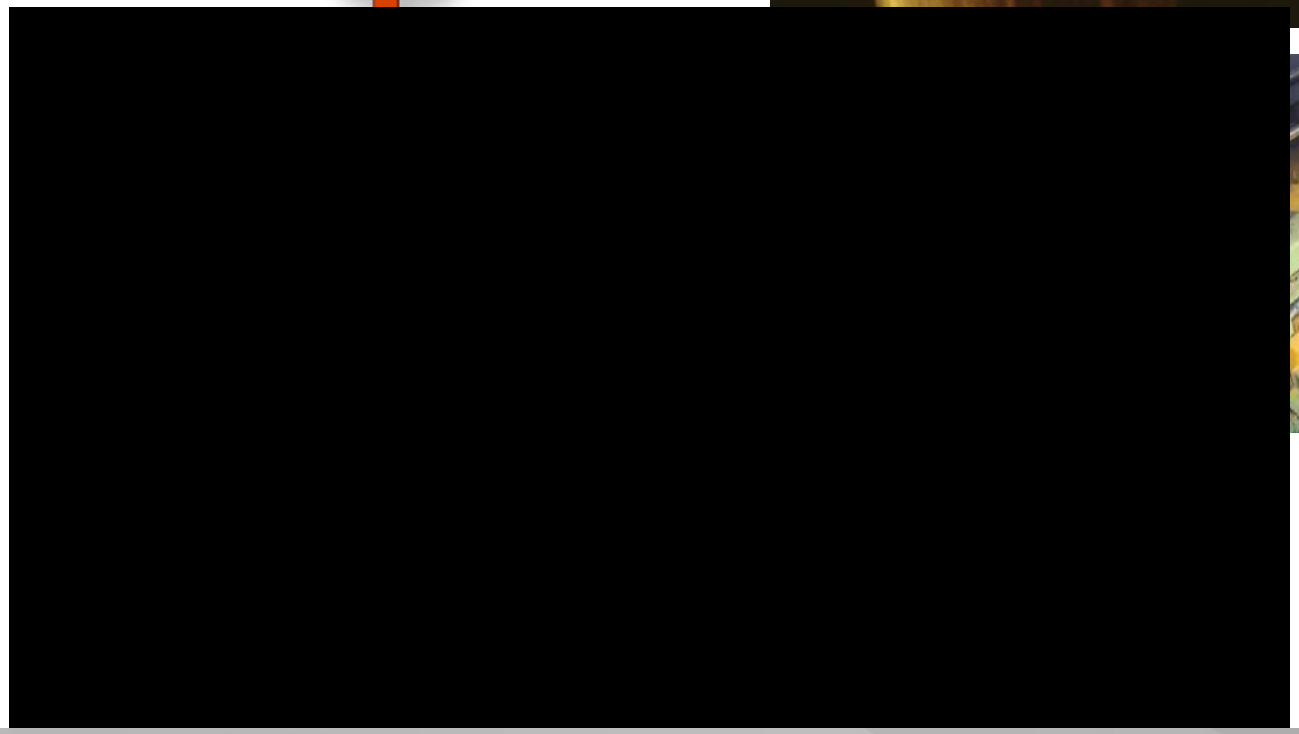
Glass wool manufacture





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Mineral wool

Products

- **boards or slabs** (λ= 0,035-0,045 W.m^{-1}.K^{-1}, ρ_V = 35 – 220 kg.m^{-3})
- **rolls** ($\lambda \cong$ 0,04 W.m^{-1}.K^{-1}, ρ_V= 70 kg.m^{-3})
- **batts, mats** ($\lambda \cong$ 0,04 W.m^{-1}.K^{-1}, ρ_V= 100-120 kg.m^{-3})
- **free wool**
- **in USA spraying on the walls** (with PVAC)

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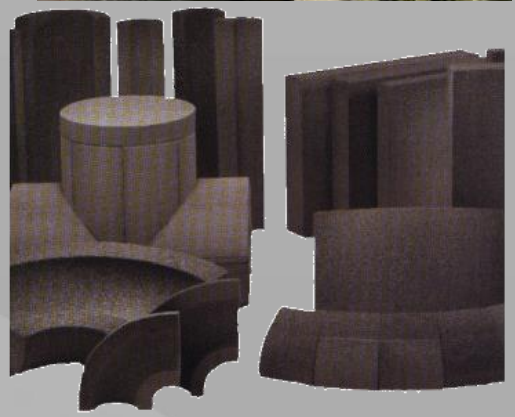
Foam (cellular) glass

- **crushed glass + coal are heated → glass sintered and gases from coal form pores**
- **$\lambda \approx 0{,}04\ W.m^{-1}.K^{-1}$**
- **$\rho_v = 100 - 150\ kg.m^{-3}$**
- **compressive strength 0,7–1,6 MPa**
- **non-combustible**
- **low absorption** (closed pores)
- **biological and chemical resistant**
- **thermal resistance (**- 260 ºC to + 430 ºC)



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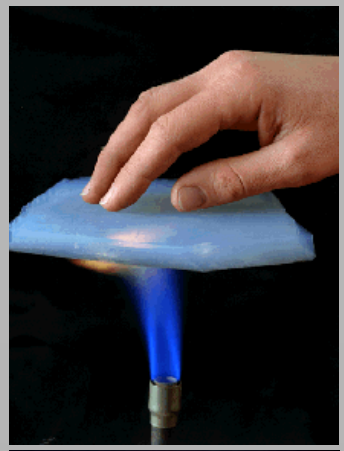
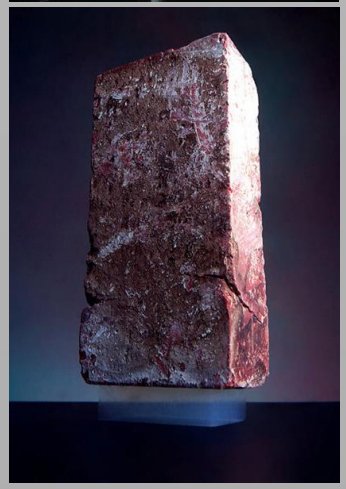
Silica aerogel





- porous material derived from a gel, in which the liquid component of the gel has been replaced with a gas
- a pure silica nanofoam
- λ = 0,004 W.m^{-1}.K^{-1}, ρ_v = 1,9 kg. m^{-3}

Building aerogels

Thicknesses[1]	5 mm 10 mm
Width[1]	1.475 m
Thermal Conductivity[2]	15.0 mW/m-K
Colour	Grey
Euro Fire Performance	C,s1,d0
Water Vapour Transmission	μ ≈ 5