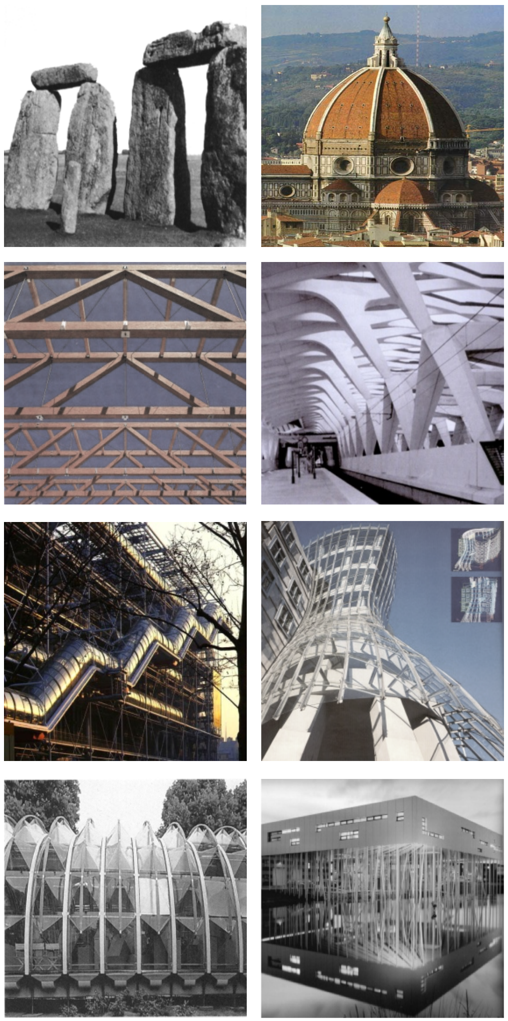
Materials for Architecture and Technological Innovation (6 CFU)

Materials Technologies for the Environment (6 CFU)

Prof. Alberto De Capua



MpA 2 Structure and quality of building materials

University of Reggio Calabria Mediterranean Studies - Architecture

dArTe
Dipartimento Architettura e Territorio

Quality of building materials

In a language that is not too specialized, the term "material quality" can mean many things: high strength, precise geometry and size, durability, good insulation, pleasant appearance ...

Generally, "quality" means "good quality" and, at the same time, "high cost".
In reality, these aspects concern the "properties" of a product and in order to have a correct idea of quality it is necessary that these properties are considered in the perspective of the use for which the product is intended.

Quality is the aptitude for use, the relationship between the objective of use and the performance of the material element.

A concept that coincides with that of "appropriate choice" and the right use of materials.

A distinction must be made between "abstract quality" and "economic quality".

AZIONI DELLA NORMATIVA

AZIONI DELLA NORMATIVA

individuazione del bisogno

metodologie da seguire

requisiti e controllo delle prestazioni

- unificazione
- nomenclatura
- caratteristiche e prove

CONFRONTO

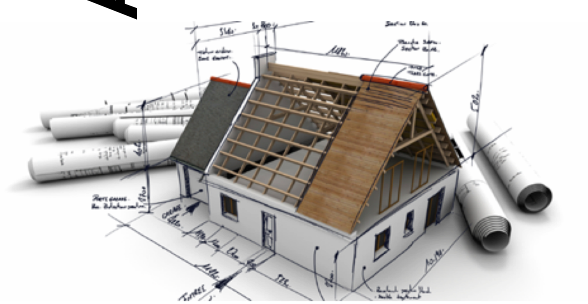
OBIETTIVI

PRESTAZIONI DEGLI ELEMENTI TECNICI

QUALITA' = VALORE D'USO

Disponibilità finanziaria-valutazioni opportunità di spesa (costo/beneficio)

QUALITA' ECONOMICA



Determination and quality control of materials

In order to implement or control "quality", we need a regulatory framework, i.e. a structured set of standards, "conventions" between producers and consumers.

...or documents containing the definition and characteristics of a material, with maximums and minimums of tolerance and an indication of the methods (tests) to be followed in determining the characteristics themselves.

These conventions, which are produced and approved by recognised authorities, contain:

the specifications of the conditions to be met by the material and the related methods for determining whether the requirements are met;

the names of the products and production processes; 'unifying' conditions to make the products compatible with each other and comparable.

Regulatory bodies:

- UNI (Ente Italiano di Unificazione)
- ISO (International Standardization Organization)
- CEN (Comité Europeen de Normalisation)
- CIB (Conseil International du Batiment)
- IEC (International Electrotechnical Committee), etc.

Material characteristics and physico-chemical tests

For the verification of the characteristics of the materials, the regulations require, depending on the case, chemical, physical and mechanical tests.

Physico-chemical tests: weight, thermal conductivity, melting point, etc.
Mechanical checks: way of reacting to stress.

Mechanical checks can be carried out using:
STATIC TESTS (gradually increasing stresses) unit load or kilogram. Strength - Kg/mmq or kg/cmq, or in Newton where 1kgf = 9,81N)

DYNAMIC TESTS (sudden stresses) in "absorbed work", kilograms kgm or kgm/cmq, or Joule where J=9.81 kgm)

FATIC TESTS Due to repeated (cyclical) stresses

Characteristics of materials or technical indicators

The elements that, directly or indirectly, determine the "quality" of the material are:

Primary characters

Physical characteristics

Mechanical characteristics

Technical and technological characteristics

Primary characters

- *composition: chemical nature of the material*
- *constitution: genesis of the material, how it was formed geologically*
- *structure: composition of the components (percentage and mode)*
- *colour: presence of pigments (appearance, which varies over time)*

WEIGHT OR DENSITY - P = g/cmc or kg/mc

It is the weight of the unit of volume considered in the state of integrity (it conditions the design of the structures and the transport costs).

It is also called "apparent specific weight" to distinguish it from the "real specific weight", which defines the "absolute density" of the material, i.e. the weight of the volume without voids.

The ratio between these two "weights" determines the COMPACTICE of the material, which is usually indicative of its mechanical strength.

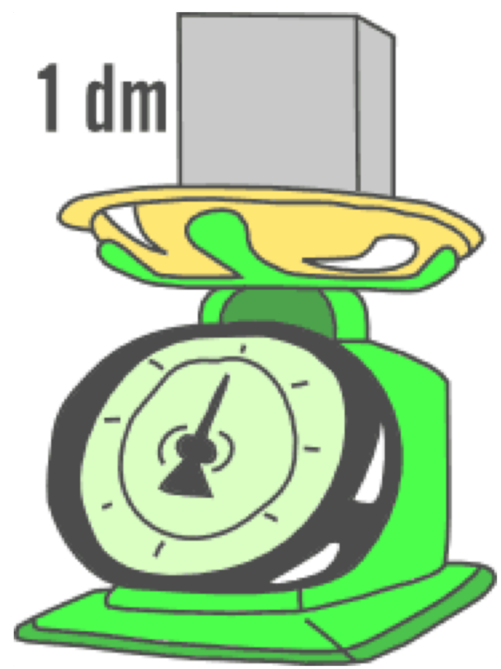
Some values of P:

wood: from 0.51 to 1.01 g/cmc

solid bricks: from 1,60 to 1,80 g/cmc

concrete: from 2.10 to 2.50 g/cmc

- steel: from 7,50 to 8,10 g/cmc



Caratteristiche fisiche

IMBIBITION, g =(Gm-G)/G

G = weight of the dry test specimen

Gm = weight of the sample saturated with water

Ability to let liquids penetrate and retain them

- Carrara marble, g = 0,001
  sandstone, g = 0,015
  volcanic tuff, g = 0,274

ABSORPTION OR HYGROSCOPICITY

Ability to absorb liquids by capillarity;
depends on the porosity

PERMEABILITY

Properties of letting liquids through or not;
may depend on both porosity and
from the finest cracks in the world.

THERMAL DILATABILITY

It is the property that materials have to increase their size if you increase the temperature.

The "coefficient of thermal expansion" is particularly high in metals and organic polymers.

L / L t L = sample length

L = length increase

t = temperature rise

wood (parallel to the fibres) = 0,000006-0,000003;

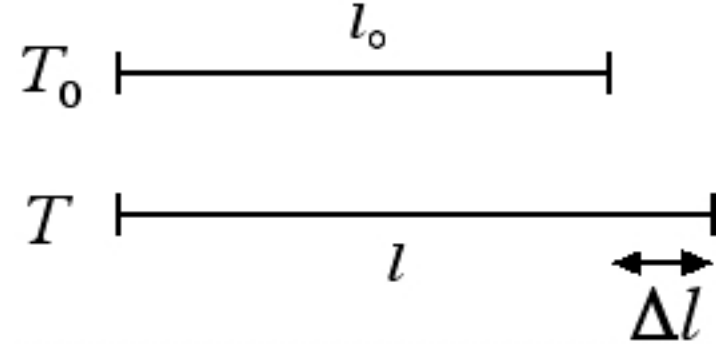
wood (perpendicular to the fibres) = 0,000055-0,000035

bricks = 0,000006

Concrete = 0,000012

steel = 0,000012

aluminium = 0,000024



Physical characteristics

THERMAL CONDUCTIVITY

It is the property that materials have to let heat pass through them, it depends on the density and also on the degree of humidity.

Q = (t2-tl)Sh / s = coefficient of thermal conductivity

Q = quantity of heat flow

by setting (t2-tl), S, h, s, = 1

Q =

(expressed in calories or joules or watts) .

- wood = 0,08-0,15

full bricks = 0,57-0,72

Perforated bricks = 0,15-0,64

Concrete = 0,70-1,20

steel = 10,00-52,00

aluminium = 178,00

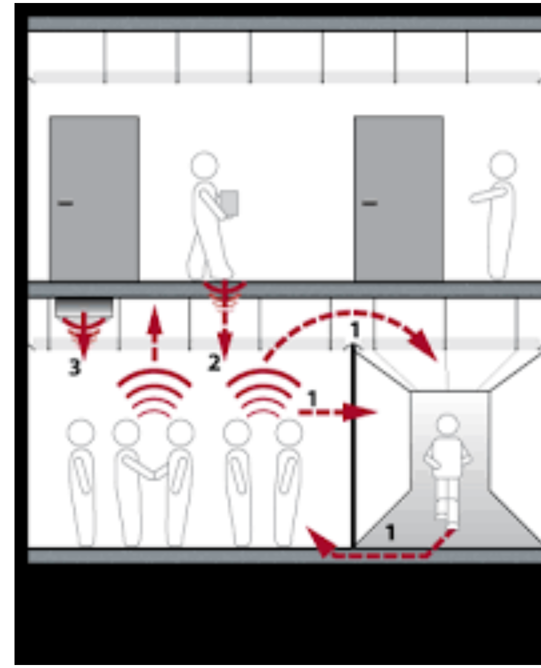
Its inverse represents the thermal resistance of the material

.

Physical characteristics

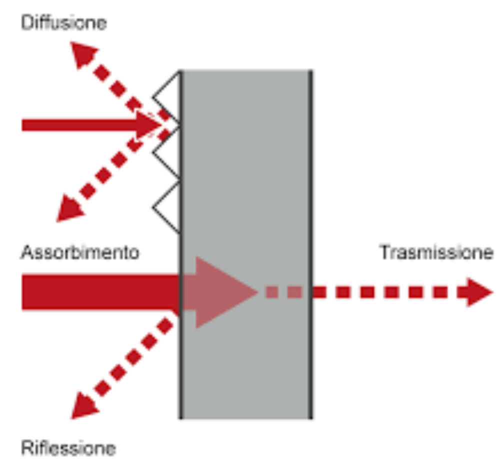
ACOUSTIC RESISTANCE

It is the property of materials to prevent the propagation of sound. Definable as the product of material density for propagation velocity which is maximum in solids and liquids, low in gases. Therefore the insulation is made with heavy materials and with closed porosity and little volume.



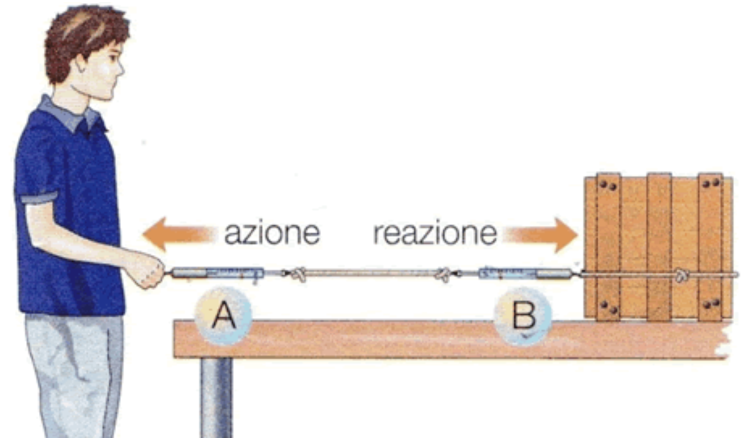
SOUND ABSORPTION

It is the ability of a material to absorb a share of sound pressure, contributing to a homogeneous and diffuse distribution of sound in the environment. It affects the listening quality of the sound. It depends on the volume of air contained in the material and on the closed or open cavity structure of the porosity.



Mechanical characteristics

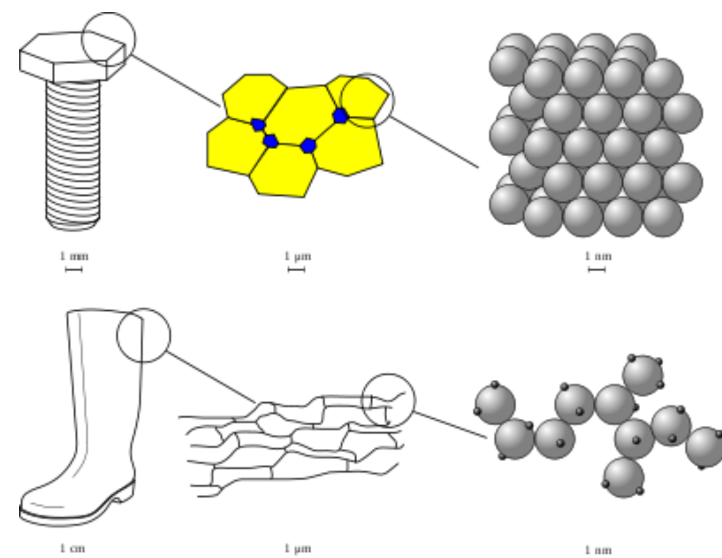
Among the basic things that are required of the building material is to withstand mechanical stress.
The problem was posed in scientific and computational terms with the birth of the Science of Construction in the nineteenth century, but the first reflections on the concept of resistance were posed long before, by physicists Galileo Galilei (1564-1642), Cristopher Wren (1632-1723) and Robert Hooke (1635-1703) and especially by Isaac Newton (1642-1727), thanks to which it was understood that when some stress occurs on a body it reacts: action and reaction are always equal and contrary (3rd principle of dynamics).



This phenomenon is explained and can be observed by X-rays.

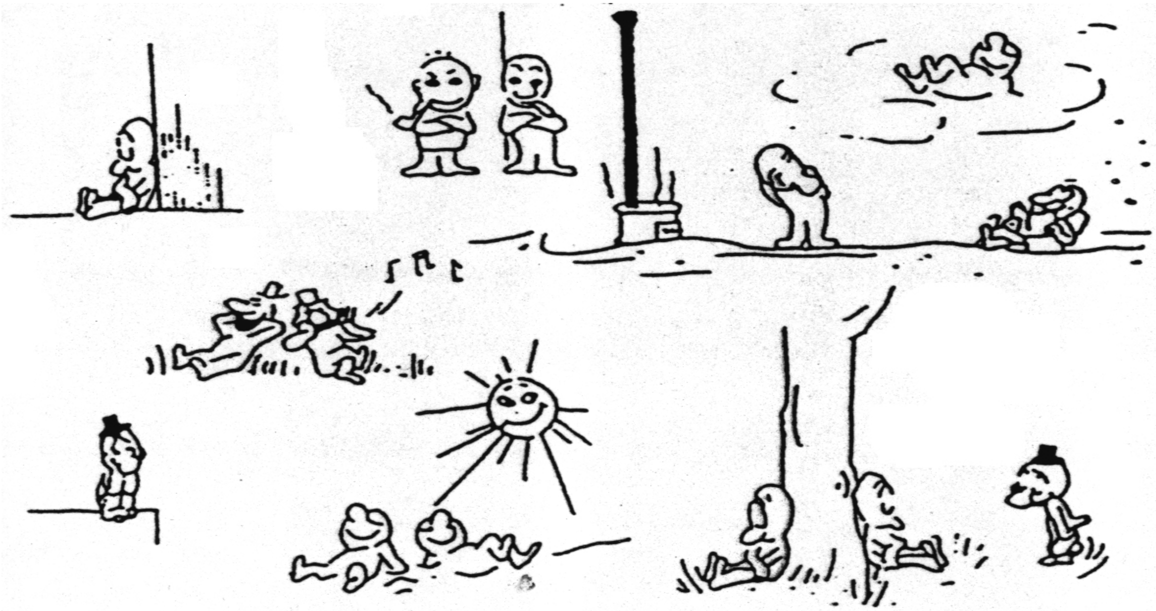
The structure of the materials appears to be formed by atoms, more or less ordered, held together by chemical bonds. These bonds can be represented as "electric springs". If the material is not stressed, the springs are "unloaded". Any attempt to approach the atoms (compression) or to move them away (traction) will shorten or lengthen the springs.

By suspending the stress, the atoms-alloys system resumes its initial configuration: the structure is "conservative".

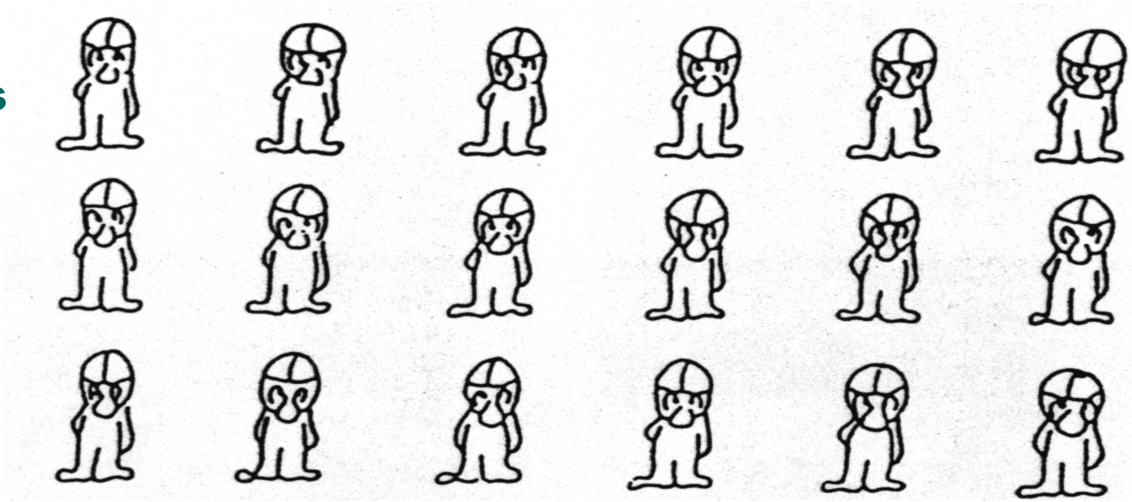


Solid bodies can be:

Amorphous when the arrangement is disorderly



Crystalline if their particles are permanently and regularly arranged in space



There are no completely rigid materials, the deformation even if imperceptible there is always and is produced by forces that overcome their "cohesion" to determine the breakage.In crystals the breakage occurs when the bonds break. In thermoplastic polymers and molecular inorganic solids, cohesive bonds are weaker, so the forces that produce deformation and rupture are also lower, so it can be said that knowing the number of atoms and the value of the cohesion bonds it is possible to calculate the resistance of a material, in practice, the stresses that cause rupture are lower (from 10 to 100 times), the reason is in the defects in the materials: "inclusions" (impurities) or "dislocations" (structural defects).

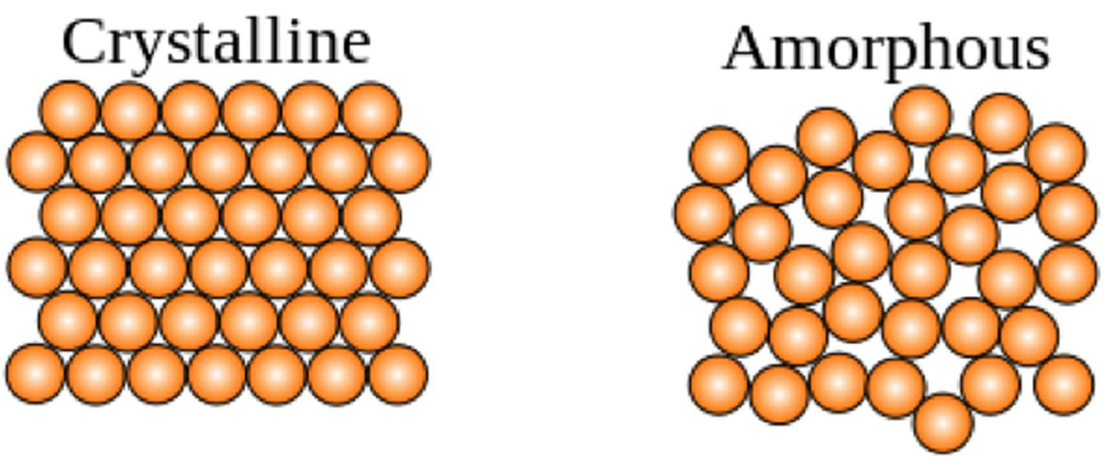


Tabella proprietà fisiche e meccaniche di metalli (valori mediati).

Materiale:		Modulo di elasticità alla trazione (Young).	Carico di rottura alla trazione.	Peso specifico, massa volumica.	Coef. di dilatazione termica.	Calore specifico.	Resistenza elettrica.	Cond. termica.	Temp. di fusione.
		E	Rm	p.sp	c	c.sp	Ω(ohm)	k	
		N/mm^2	N/mm^2	kg/dm^3	mm/m/ °C	kcal/kg	ohm/mm^2 m	kcal/m °C	°C
Ferro	Fe 37/360	190000	360	7,87	0,0123	0,12	0,0934	68	1550
Ferro	Fe 430	200000	430	7,87	0,0108	0,12	0,0934	68	
Ferro	Fe 510	210000	510	7,87	0,0108	0,12	0,0934	68	
Acciaio non legato	C40	220000	500	7,87	0,0108	0,12	0,142	57	1515
Acciaio non legato	C 45	220000	680	7,87	0,0108	0,12	0,142	57	
Acciaio legato	18NiCrMo5	230000	980	7,87	0,0124	0,12			
Acciaio legato	34CrNiMo6	220000	1100	7,87	0,0124	0,12			
Acciaio legato	42 CrMo 4	230000	1050	7,87	0,0124	0,12			
Acciaio per cilindri	St35 - St37	200000	480	7,87	0,0124	0,12			
Acciaio per cilindri	ST 52	220000	580	7,87	0,0124	0,12			
Acciaio per cilindri	ST E 460	220000	700	7,87	0,0124	0,12			
Acciaio INOX	AISI 304 X5CrNi 18-10	196000	515	7,91	0,0165	0,12	0,714	12,9	1398

Acciaio INOX	AISI 316 Z5CrNiMo 17-12-2	196000	515	8	0,0165	0,12	0,714	12,9	
Acciaio INOX	AISI 410 X12 Cr 13	198000	730	7,9	0,011	0,11	0,6	25,8	
Acciaio INOX	AISI 420 X30 Cr 13	198000	800	7,9	0,011	0,11	0,6	25,8	
Acciaio INOX	AISI 430 X6 Cr 17	200000	500	7,9	0,01	0,11	0,6	21,5	
Acciaio INOX	AISI 630 X5CrNiCuNb 16-4	196000	1200	8	0,011	0,12	0,7	13,8	
Acciaio INOX	AISI 904 X1NiCrMoCu25-20-5	192000	540	8	0,0161	0,108		10,3	
INOX temprato	X105 Cr Mo 17	196000	825	8		0,12			
Corten	Corten B	206000	500	7,87	0,0123	0,12	0,093	60	
		N/mm^2	N/mm^2	kg/dm^3	mm/m/ °C	kcal/kg	ohm/mm^2 m	kcal/m °C	°C
		E	**Rm**	**p.sp**	**c**	**c.sp**	**Ω(ohm)**	**k**	
		Modulo di young.	Carico di rottura alla trazione.	Peso specifico, massa	Coef. di dilatazione termica.	Calore specifico.	Resistenza elettrica.	Cond. termica.	Temp. di fusione.

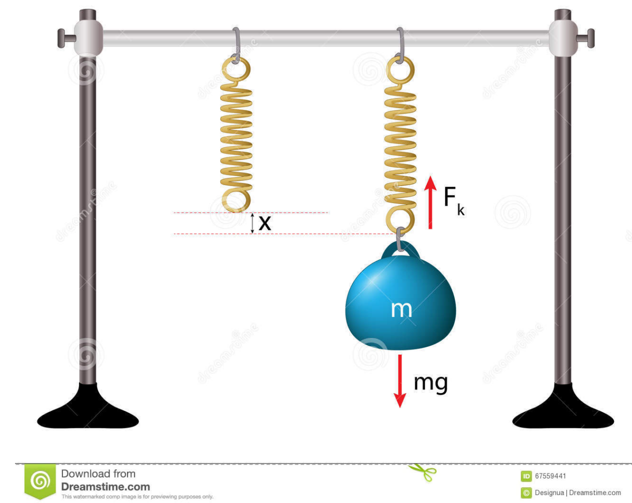
Hooke's Law

The load applied to a body is proportional to the induced deformation.

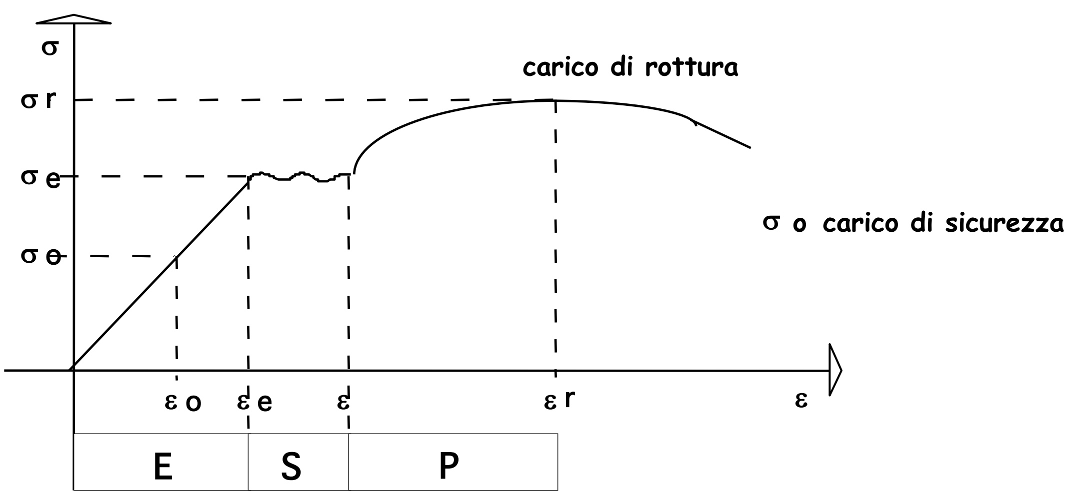
Example: if a metal wire, under a load of 100 kg, stretches by 1 cm, under a load of 200 kg it will stretch by 2 cm.

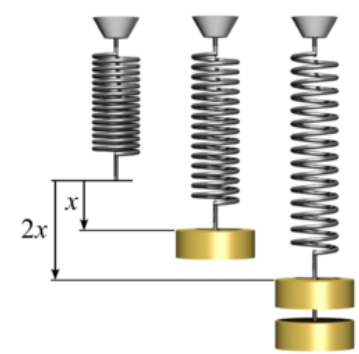
In reality, this is only partially true: for very large deformations the stress is anything but proportional to the elongation.

For small deformations the process is reversible (elastic behaviour); beyond certain values, it is irreversible (plastic behaviour).



The relationship between the variation of σ and ε is given by the Hooke diagram





E = fase elastica S = fase di snervamento P = fase plastica

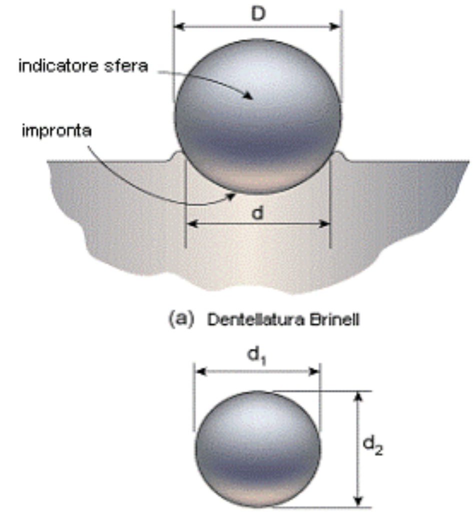
Mechanical resistance is the ability to withstand internal stresses produced by external forces: - traction - compression - bending (compression + traction) - cut – torsion

For each material it is possible to determine the LOAD OF ROTTURE, given by the ratio between the load corresponding to the breaking point in the Hooke diagram and the value of the section of the material at the same time.In the design of the structure, the SAFETY LOAD is taken into account, which is a fraction of the breaking load and which defines the maximum stress that ensures that no irreversible deformation will occur.-

This fraction number expresses the SAFETY GRADE "K", which varies with the variation of the material:
steel K = 1,5-2,3
wood K = 4-6
stone and brick materials K = 8-15

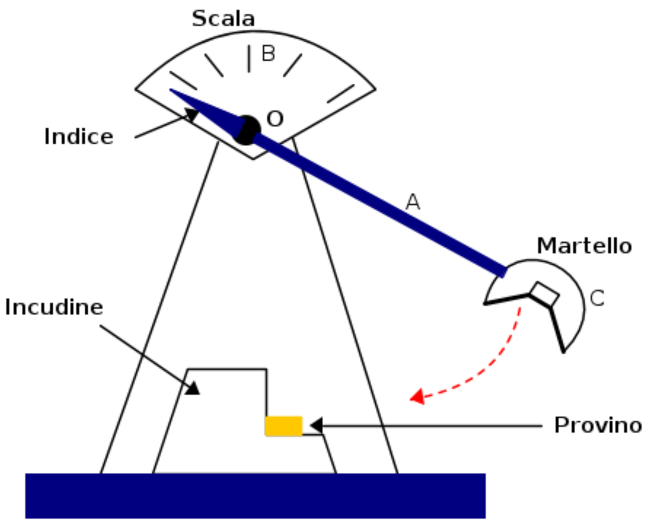
Among the mechanical characteristics, in addition to the strengths mentioned for normal structural purposes, it is necessary to remember:

HARDNESS or ability to resist actions that tend to affect it (cutting, abrasion, engraving, penetration, etc.).

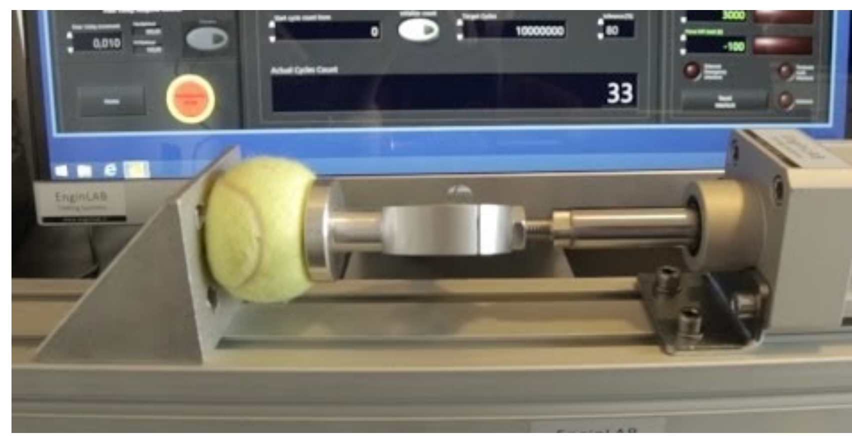


(a) Dentellatura Brinell

(b) misurazione dell'impronta del diametro



RESILIENCE or energy that a material can absorb when subjected to an impact, without reaching breakage



FATIC RESISTANCE refers to cases in which a body is cyclically stressed with minimum loads and high loads that cause "fatigue", greatly reducing the breaking load.

The characteristics described include substantially "destructive" verification tests. Today we know and practice other tests that provide equally reliable information without affecting the material (X-rays, ultrasound, magnetoscopic procedures, etc..).

Caratteristiche tecniche e tecnologiche

CARATTERISTICHE TECNICHE E TECNOLOGICHE *Rapporto tra le caratteristiche intrinseche dei materiali e le "esigenze" (normativa della qualità)* **Classi di esigenze (UNI 0050)**		
Sicurezza	Stabilità	• Resistenza meccanica alle azioni statiche • Resistenza alle azioni dinamiche
	Sicurezza al fuoco	• Resistenza reale • Assenza di emissione di sostanze nocive
	Sicurezza d'uso	• Controllo della scabrosità • Antisdrucciolevolezza • Comodità d’uso e di manovra
Benessere	Igrotermici	• Controllo del fattore solare • Impermeabilità ai liquidi • Controllo dell’inerzia termica • Tenuta all’aria
	Acustici	• Assorbimento acustico • Isolamento acustico
	Visivi	• Assorbimento luminoso • Controllo dei fenomeni di abbagliamento
	Olfattivi	• Assenza di emissione di odori • Impermeabilità ai fluidi aerei • Tenuta alle polveri
	Tattili	• Controllo della scabrosità
Fruibilità	Attrezzabilità	• Possibilità di fissare elementi
	Comodità d’uso e di manovra	• Raggiungibilità elementi e manovrabilità
	Accessibilità e utilizzabilità	• Agibilità delle parti e raggiungibilità dispositivi

CARATTERISTICHE TECNICHE E TECNOLOGICHE		
Aspetto	Appropriatezza dell'immagine	
	Conservazione dell'immagine	
Integrabilità	Integrazione dimensionale degli elementi tecnici	
	Giunzionabilità	
	Integrazione edilizia degli impianti	
Gestione	Economie di esercizio	come requisiti di benessere
	Economie di gestione	• Conservazione prestazioni nel tempo • Durevolezza • Pulibilità