YILDIZ TECHNICAL UNIVERSITY – DEPARTMENT OF ARCHITECTURE
2017 -2018 ACADEMIC YEAR – SPRING SEMESTER
BUILDING MATERIALS LECTURE NOTES / Dr. Polat DARÇIN

PROPERTIES OF BUILDING PRODUCTS

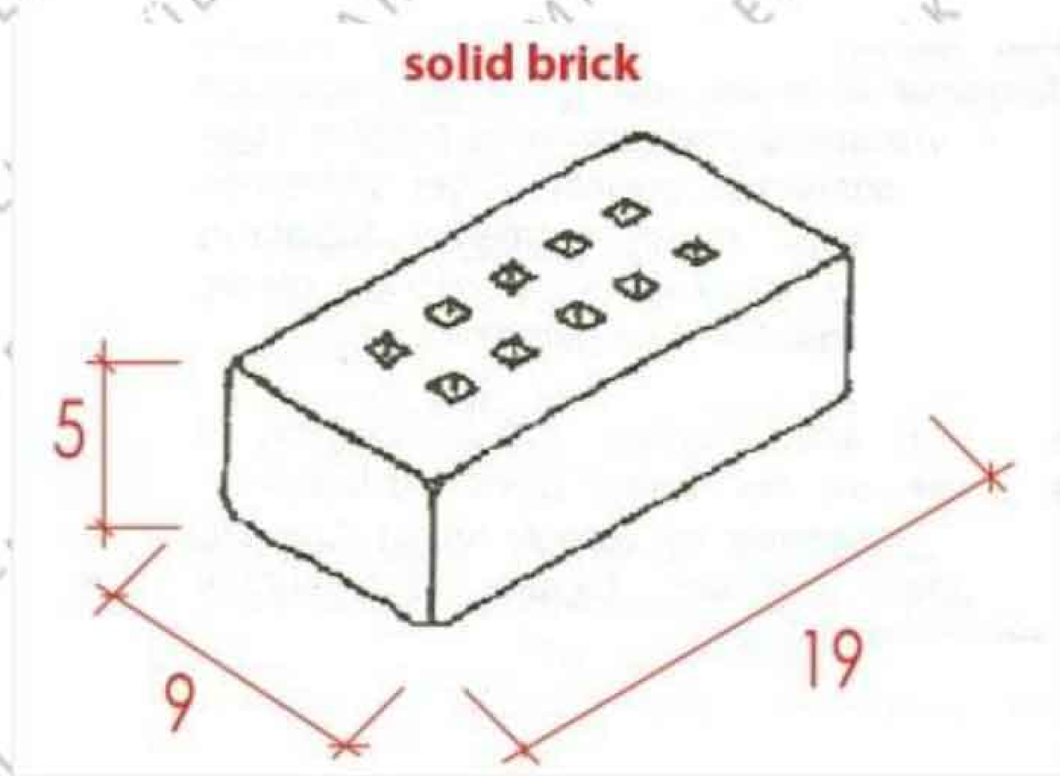
Properties of building products are important due to classification, arrangement of the information, improvement and selection of products (Balanlı, 1997). Especially for architects, a comprehensive knowledge of the properties of building products allows a rational choice for aesthetical and functional design via determining and comparing different options.

The general properties of building products can be classified as (Çayak, 2005).

- visual properties
- physical properties
- mechanical properties
- technological properties
- physicochemical properties
- properties related to human health
- properties related to usage
- properties related to production and application
- financial properties

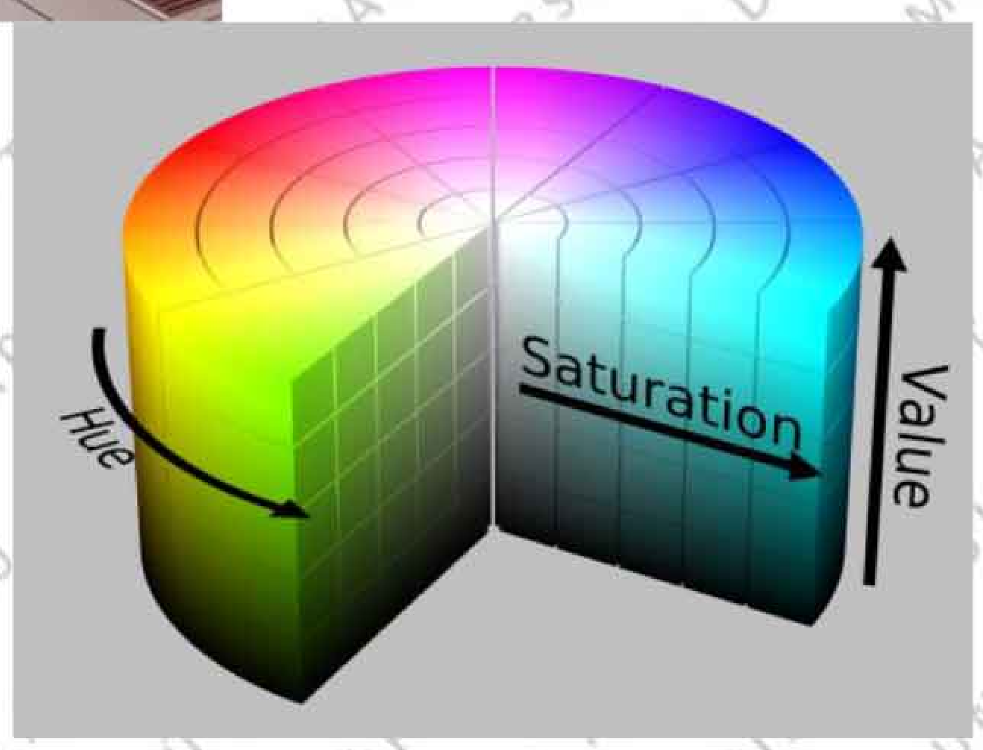
visual properties of building products:

size width, length and height of products



form geometrically definable or amorphous shapes of building products

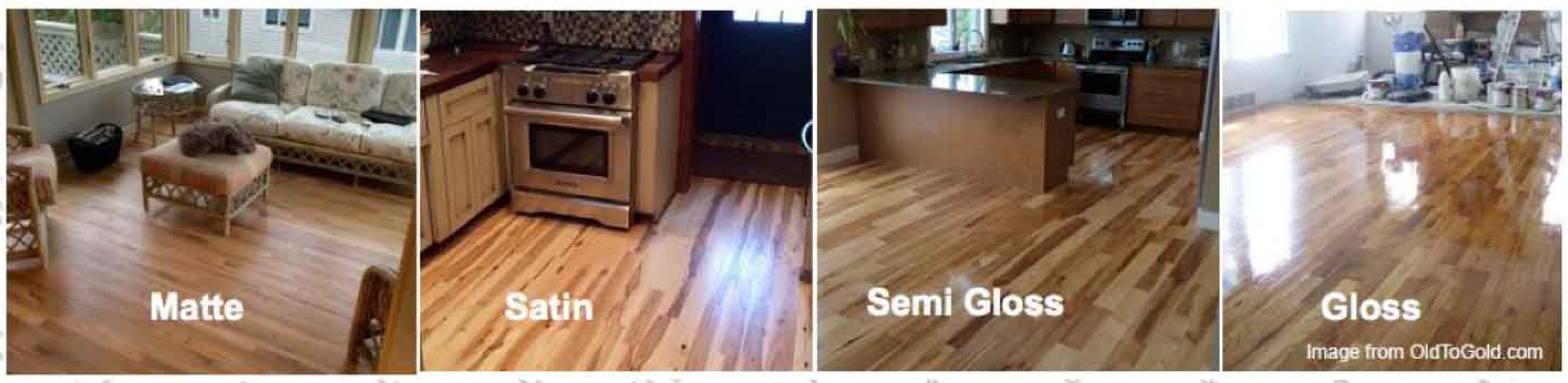
color hue, value and saturation of color of building products



pattern arrangement of lines, shapes, colors etc. on the surface of building products

texture smoothness or roughness of the surface of building products

glossiness light reflection capacity of the surface of building products



transparency light transmittance capacity of building products

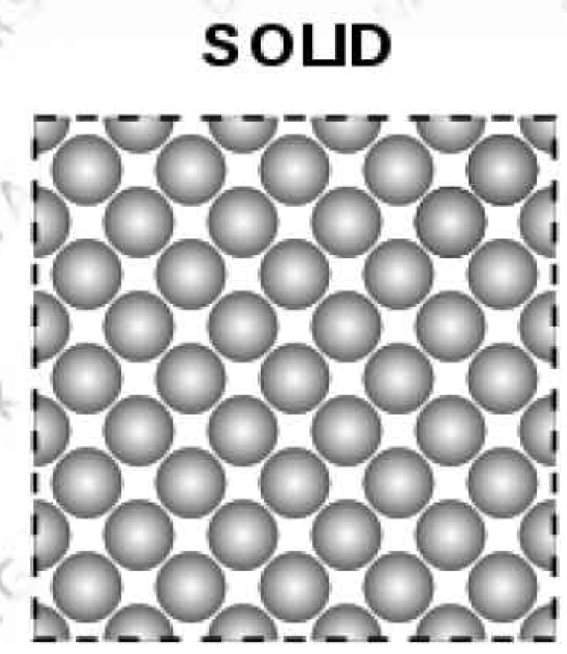
The physical properties of building products include properties which are quantifiable and observable traits that can be measured without changing the composition of the material. Some of these properties can be grouped into:

- structural properties,
- properties related to heat,
- properties related to sound,
- properties related to water and humidity

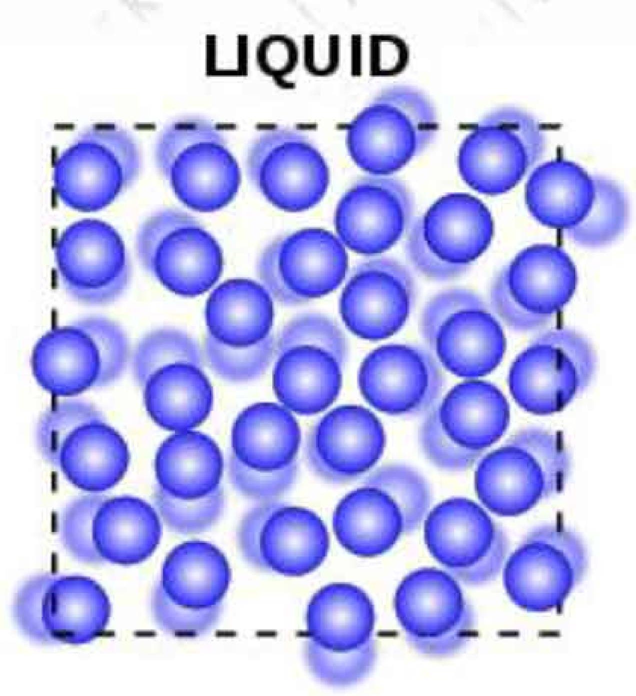
structural properties of building products:

physical state

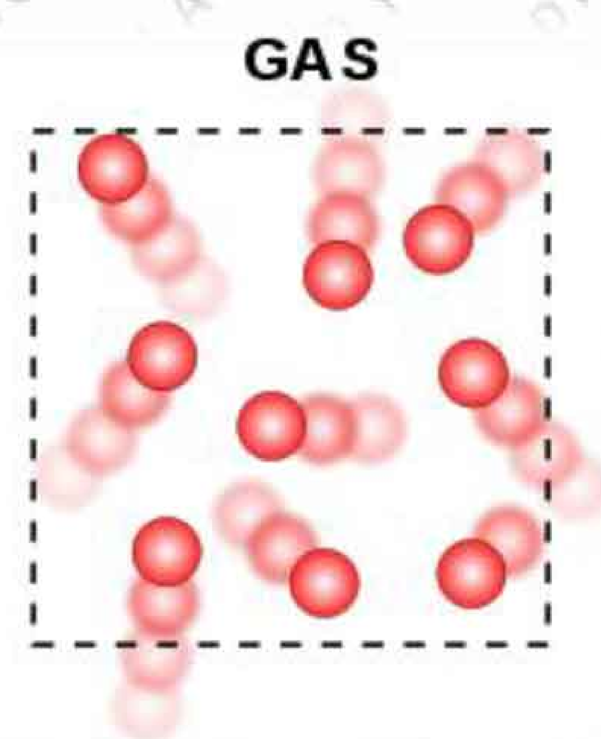
solid: particles (ions, atoms and molecules) are strong so that they cannot move freely but only vibrate. A solid has a stable, definite shape and volume.



liquid: particles have enough energy to move relative to each other, the structure is mobile which means the shape of a liquid is not definite but is determined by its container.

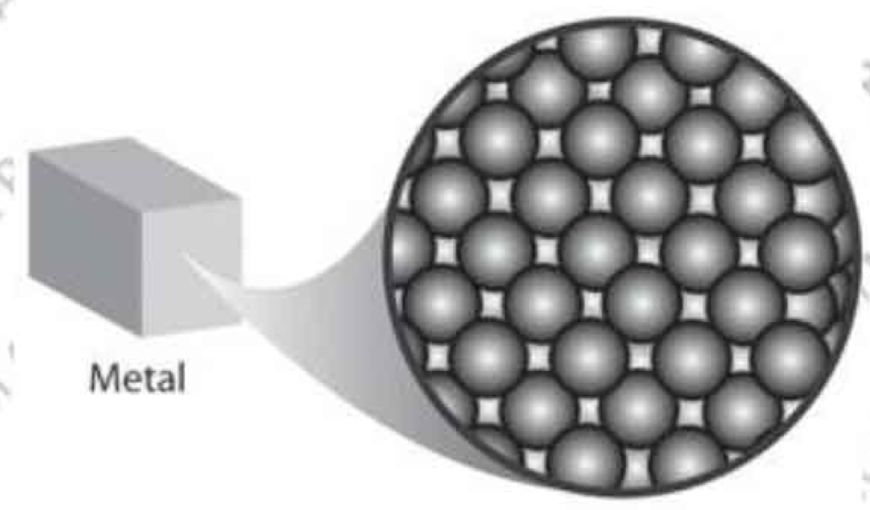


gas: particles have enough kinetic energy, the typical distance between neighboring molecules is much greater than molecular size. A gas has no definite shape or volume, but occupies the entire container.

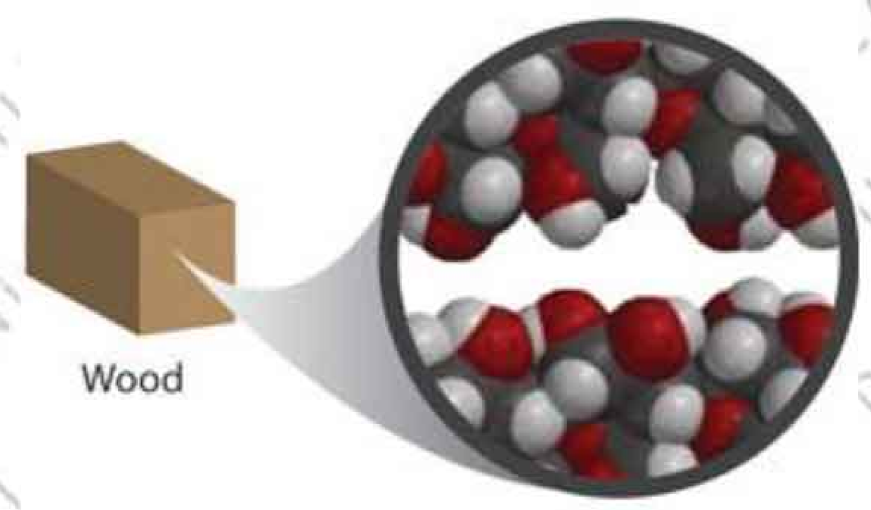


structure

homogeneous: materials which are formed by the same substances.

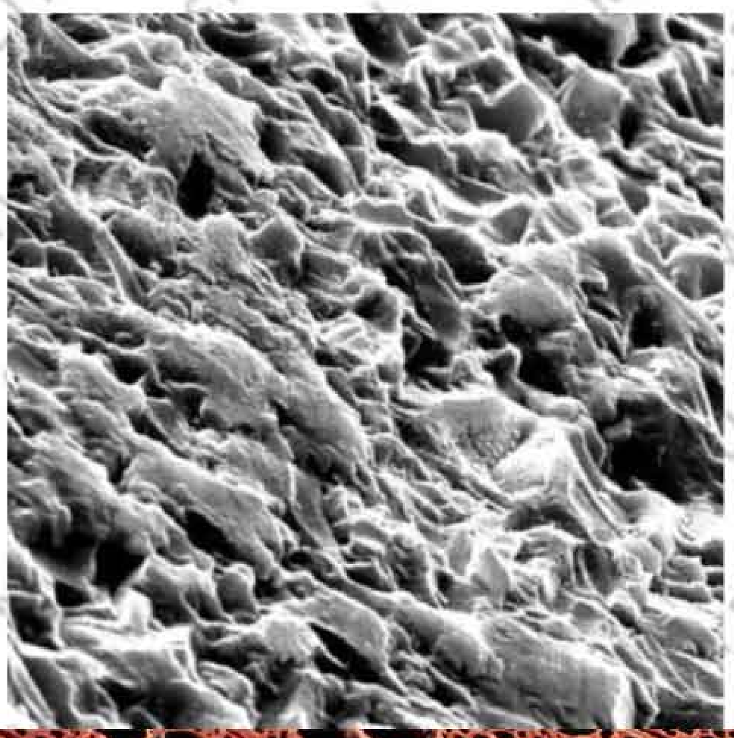


heterogeneous: materials which are formed by different substances.

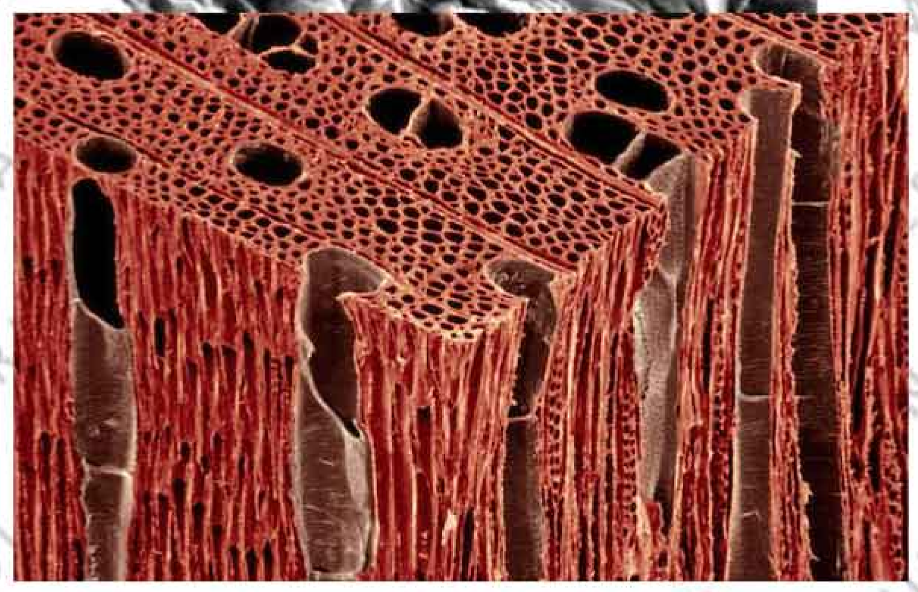


structure

isotropic: materials which have identical properties in different directions.

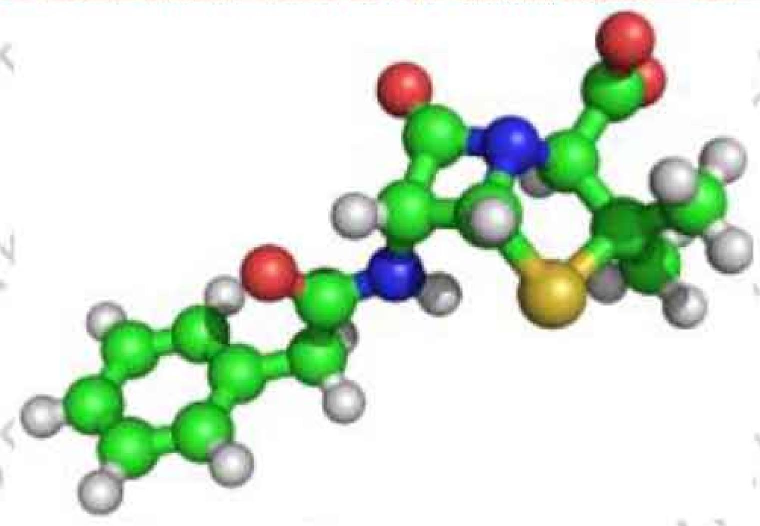


anisotropic: materials which have different properties in different directions.

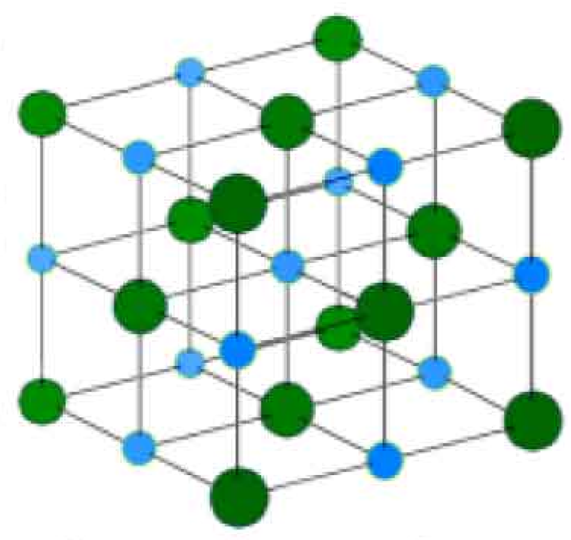


internal structure (microstructure)

molecular microstructure: molecules are made up by chemically bonding two or more atoms of the same element or different elements by covalent bonds (e.g. wood or plastics)



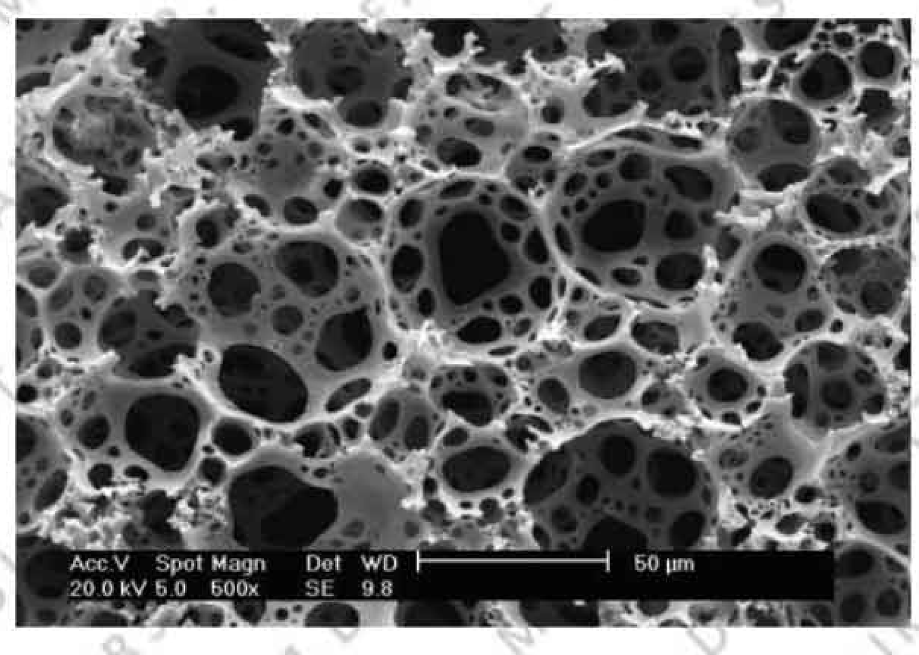
crystalline microstructure: have atoms arranged in a highly ordered three dimensional structure, forming a crystal lattice that extends in all directions (metals)



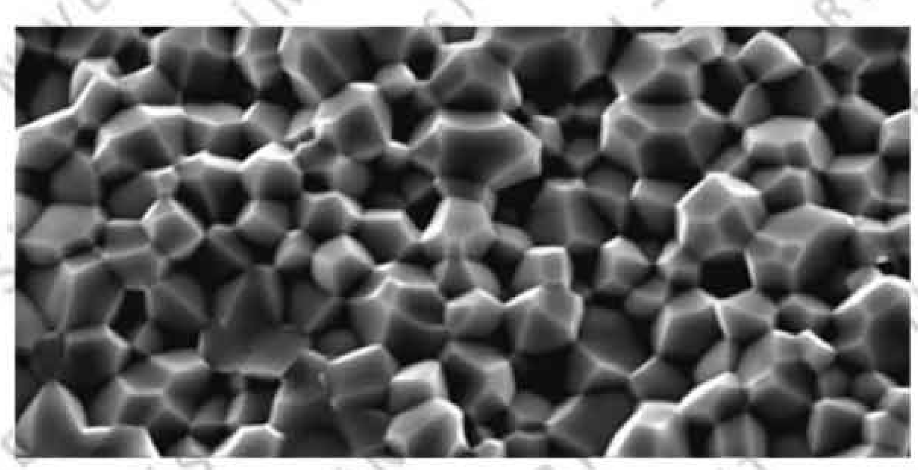
composite microstructure: have properties of both molecular and crystalline microstructures (e.g. some natural stones, concrete, glass)

compactness

porous: materials which have pores (voids) and can absorb water



non porous: materials which do not have pores and cannot absorb water



density (ρ) is the mass of a unit volume of materials.

$$\rho = \frac{M}{V} \ g/cm^3$$

M = mass (g)
V = volume (cm^3)

Material	*Density (g/cm³)*
Brick	2.5–2.8
Granite	2.6–2.9
Portland cement	2.9–3.1
Wood	1.5–1.6
Steel	7.8–7.9

bulk density (ρ_b) is the mass of a unit volume of material in its natural state (with pores and voids).

$$\rho_b = \frac{M}{V} \ kg/m^3$$

M = mass of specimen (kg)
V = volume of specimen in its natural state (m^3)

Material	*Bulk density (kg/m³)*
Brick	1600–1800
Granite	2500–2700
Sand	1450–1650
Pine wood	500–600
Steel	7850

unit (specific) weight (γ) is weight per unit volume of material.

$$\gamma = \rho \cdot g$$

Where

γ = specific weight (kN/m^3)
ρ = density of the material (kg/m)
g = gravity (m/s^2)

compactness ratio (K) is the measure of solid spaces in a material and is a fraction of the volume of solids (V_s) over the total volume (V).

$$K = \frac{V_s}{V}$$

porosity (n) is the measure of void spaces in a material and is a fraction of the volume of voids (V_v) over the total volume (V).

$$n = \frac{V_v}{V}$$

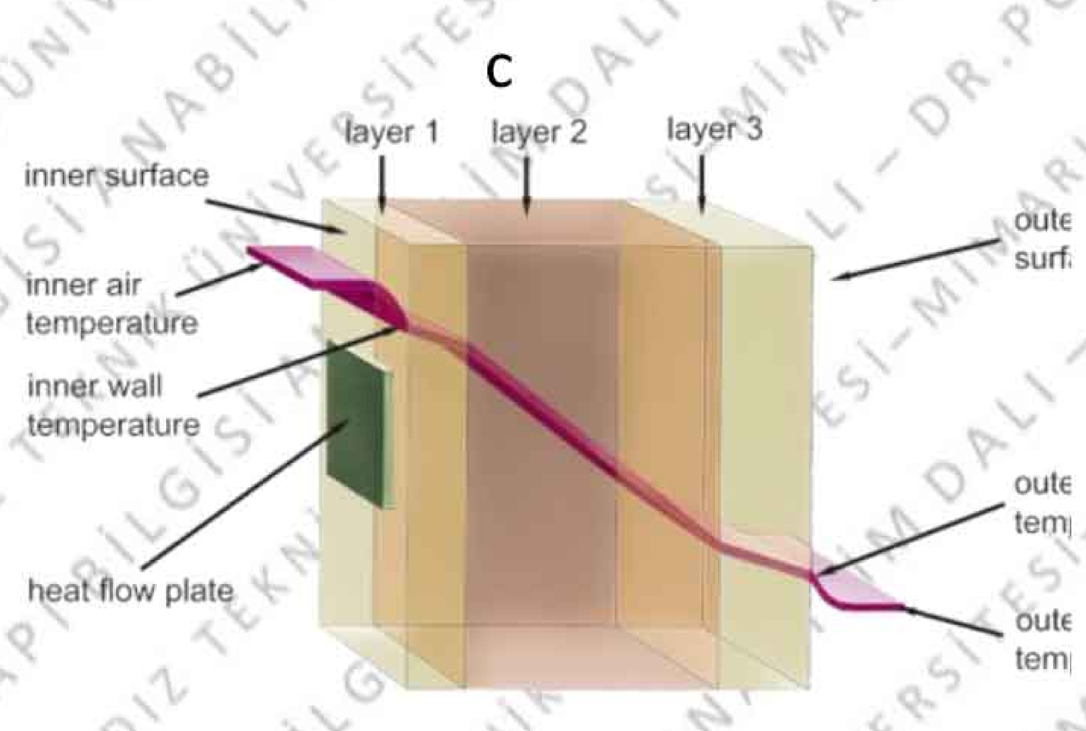
void ratio (e) is defined as the ratio of volume of voids (V_v) to the volume of solids (V_s).

$$e = \frac{V_v}{V_s}$$

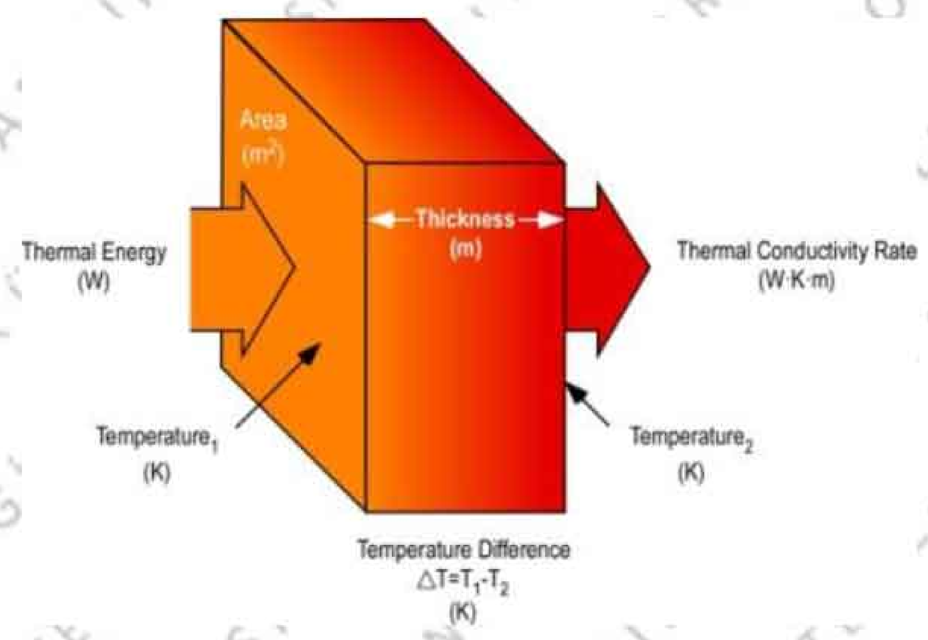
The amount of voids in a material is closely related to its properties under different conditions. If the density increases (the mass increases in a constant volume, the voids decreases), generally the material becomes more resistant and its conductivity increases as well.

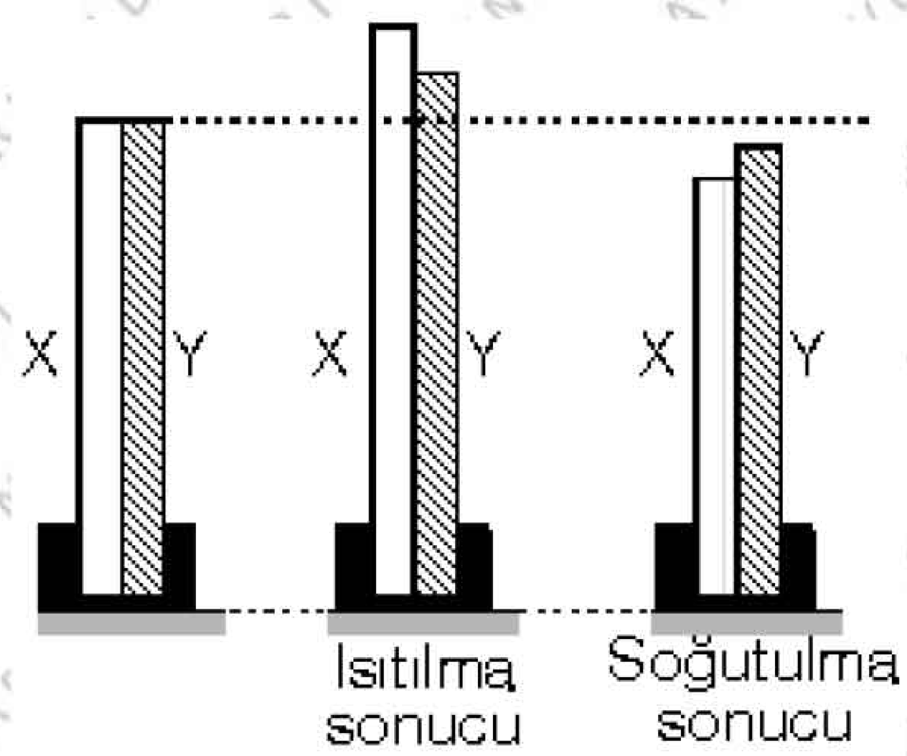
properties of building products related to heat: The amount of heat energy determines the behavior of atoms and temperatures. Due to physical properties of a material, changes in the temperature may cause this material to conduct heat energy and / or change its shape. Generally materials with low density (porous materials) are resistant to heat transfer.

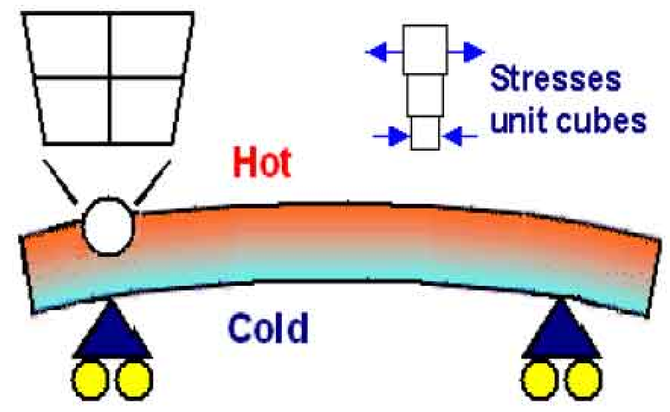
thermal transmittance (U value) is the rate of transfer of heat through one square meter of a material divided by the difference in temperatures across the material, expressed in watts per square meter Kelvin (W/m^2K). The better insulated a material is, the lower U value will be.



thermal conductivity (k or λ value)	is the ability of a material to conduct heat. Consequently, a high thermal conductivity means that heat transfer across a material will occur at a higher rate. The units of thermal conductivity are W/mK.
thermal resistance (R value)	is the ability of a material to resist heat flow (the reciprocal of U value). Higher figure indicates better performance for heat insulation
thermal expansion (α)	Is the tendency of material to change in shape, area and volume in response to a change in temperature. When a material is heated, the kinetic energy of its molecules increases, thus molecules begin vibrating more and usually maintain a greater average separation. The fractional change in size per degree change in temperature at a constant pressure is measured as thermal expansion coefficient.
thermal stress (δ)	The volumetric enlargement (expansion) or reduction (contraction) may cause cracks or breaks due to thermal stress and possible weakening and deformation.







properties of building products related to sound: sound is a vibration that propagates as a typically audible mechanical wave of pressure and displacement through a transmission medium. Transmission of sound through a material is related to its structure and density. The sound travels faster through media with higher elasticity and / or lower density.

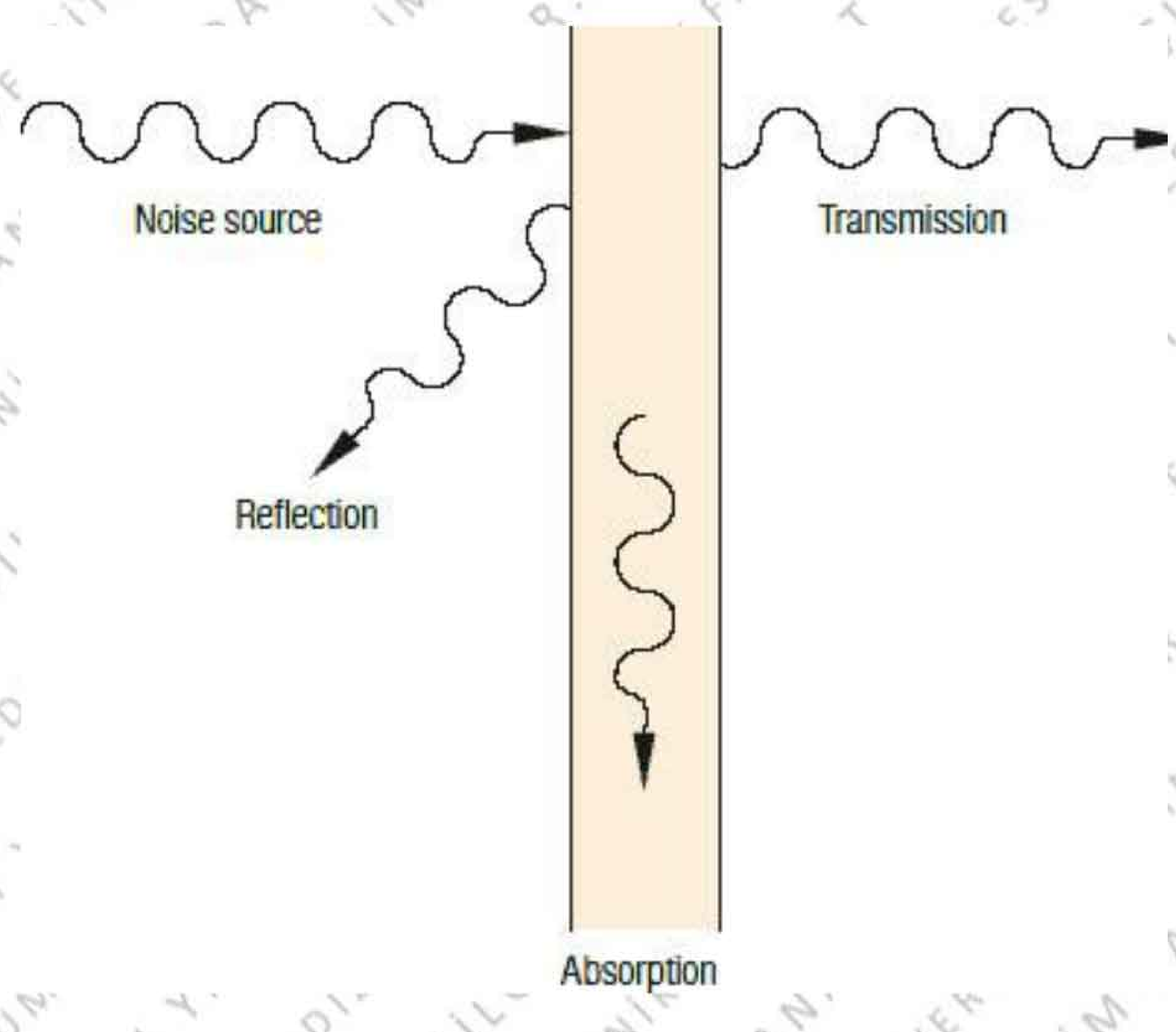
$$c = (E / \rho)^{1/2} \qquad (2)$$

where

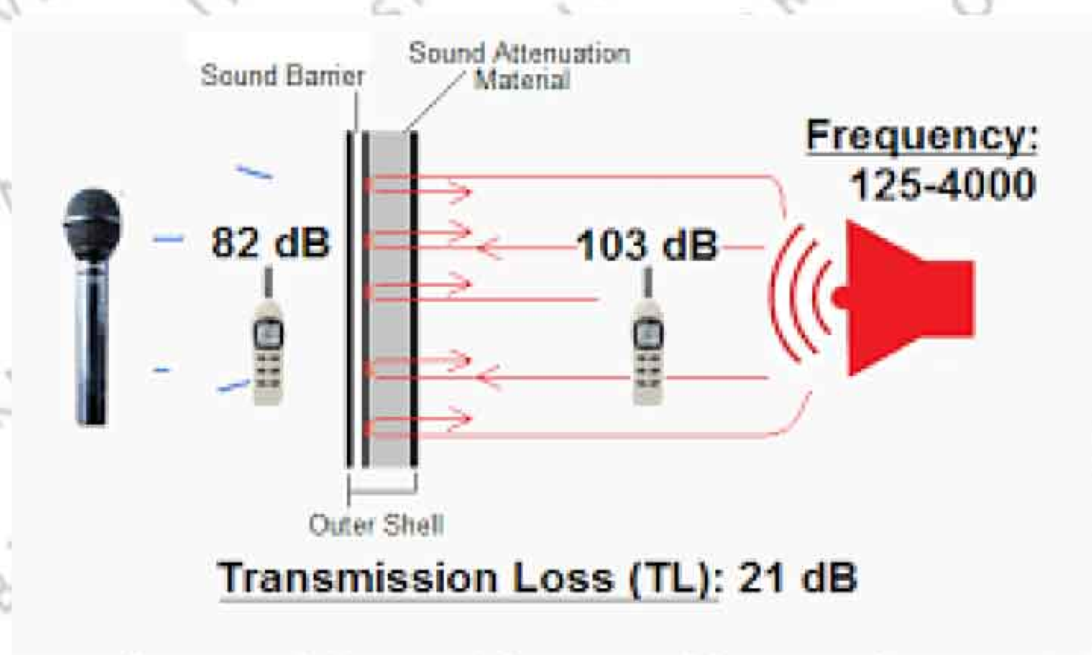
E = bulk modulus elasticity (Pa, psi)

ρ = density (kg/m³, lb/ft³)

When a sound wave encounters a solid, depending on the properties of material and its surface, some of the energy is reflected, some is absorbed and some will be transferred to the other side.

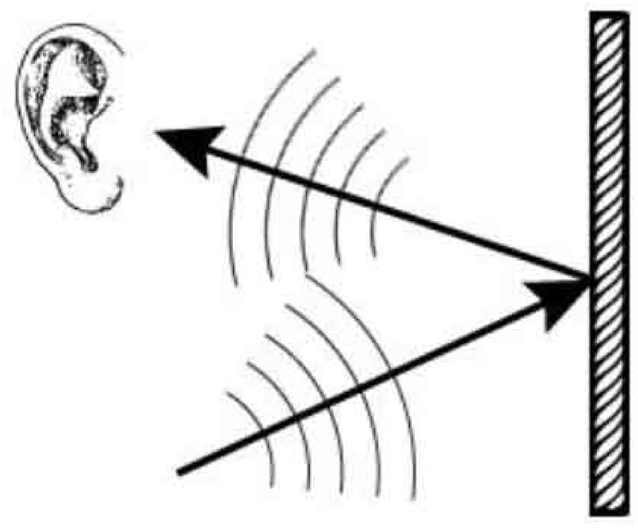


sound transmission loss (TL) is the accumulated decrease in intensity of sound energy as a wave propagates outwards from a source or as it propagates through a certain product. Sound transmission loss of a product is related to its weight, density, homogeneity, thickness, microstructure, etc.



sound absorption (α) is the process by which a product takes in sound energy when sound waves are encountered.

sound reflection (R) When an acoustic travelling wave encounters a surface, depending on its properties, it can be reflected. The portion of the wave undergoes reflection is dependent upon the dissimilarity between the media sound is travelling (e.g. air) and the media sound encountered (e.g. a concrete wall).



properties of building products related to water and humidity: According to the physical properties of a product such as microstructure, density and porosity, the relationship of the product with water in its liquid and gas states changes. Generally, low density porous materials absorb water and humidity, which may cause a change in their properties.

water absorption capacity by weight (S_a) The difference between waterlogged weight (P_1) of a product and its dry weight (P_0) over its dry weight (P_0) is the water absorption capacity (%) by weight.

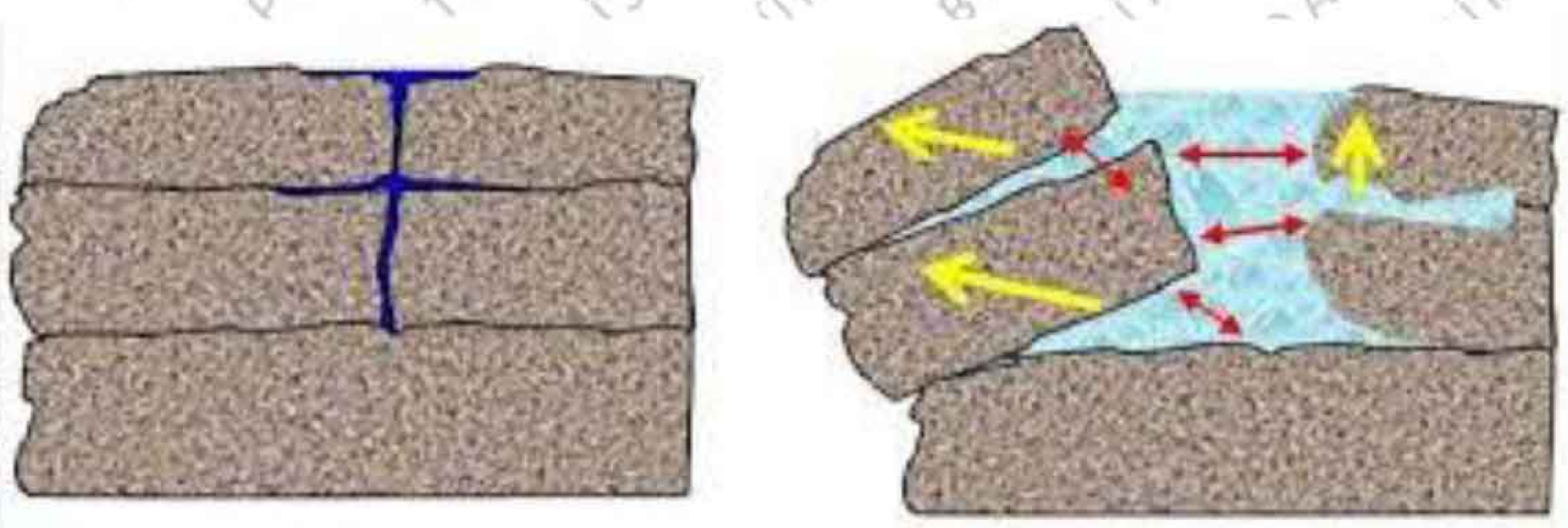
$$S_a = \frac{P1 - Po}{Po} 100$$

water absorption capacity by volume (S_h) / apparent porosity The volume of absorbed water over the total volume of product is the water absorption capacity of this product by volume.

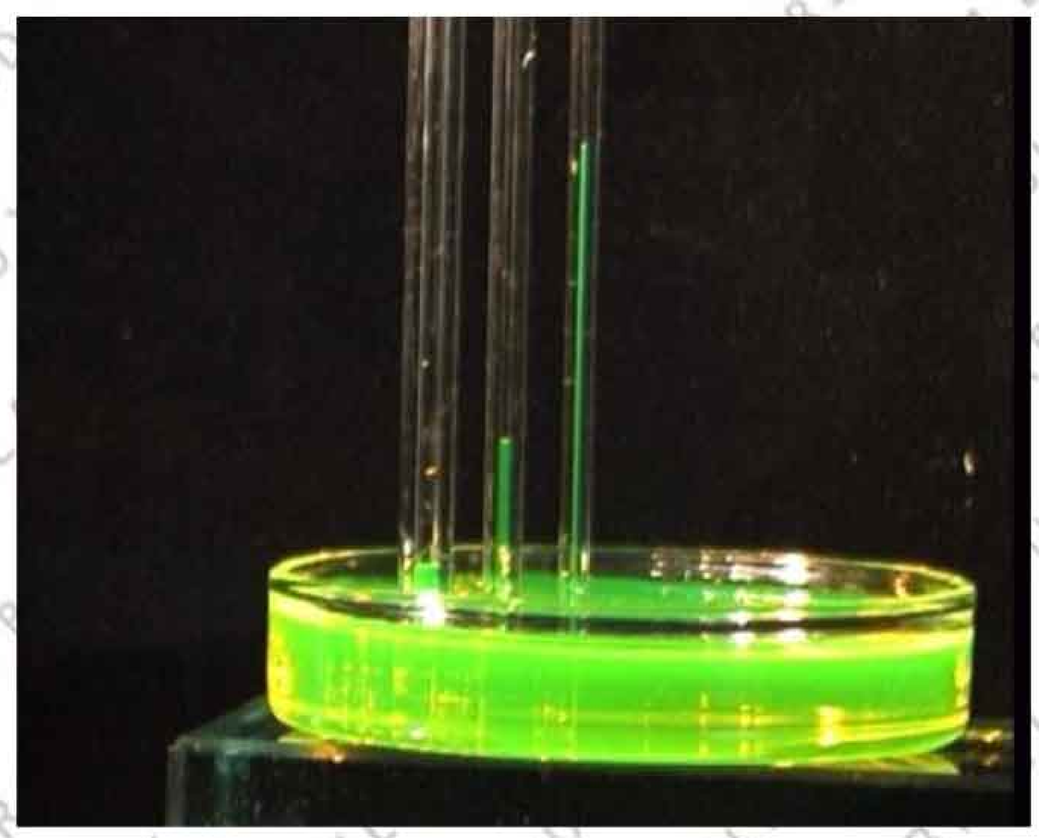
$$S_h = \frac{P1 - Po}{V} 100$$

degree of saturation is a ratio of liquid to the total volume of voids in a porous material. This value shows how much of the total void of material can absorb water. The degree of saturation mainly depends on the properties of pores, if the material has closed pores, it may not absorb water.

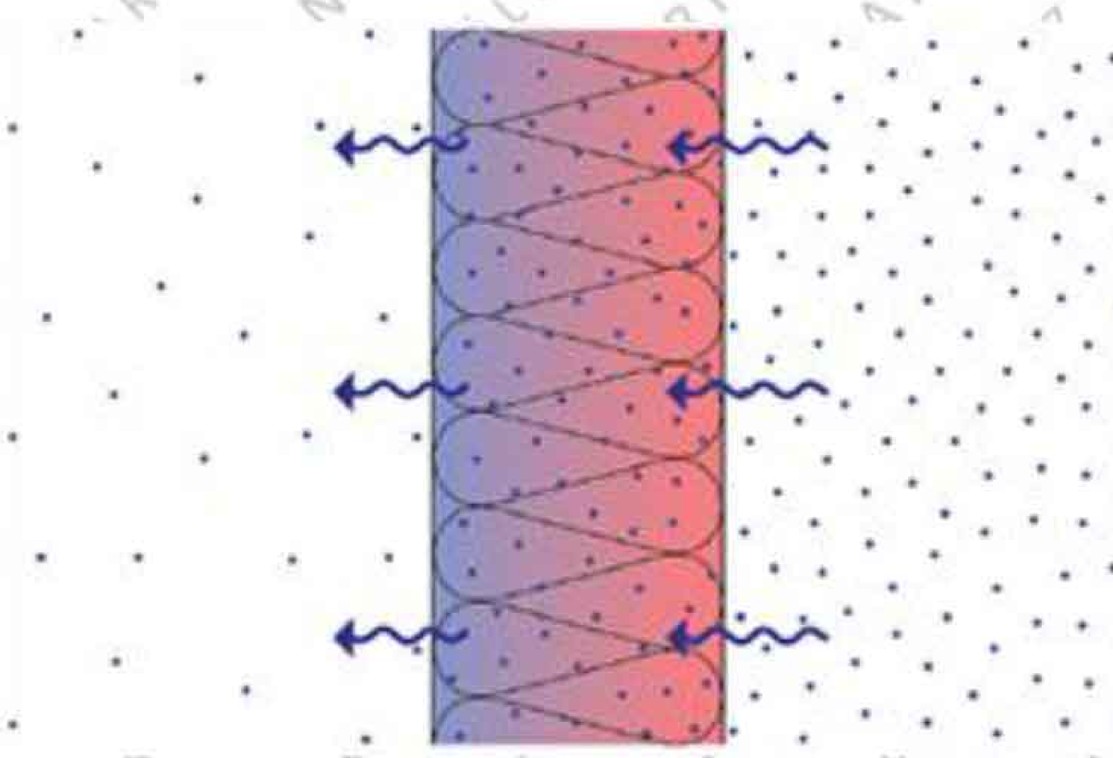
The water in the voids freezes if the temperature is under 0°C. When the water freezes, the volume of water expands by 10%. If the material is fully saturated, the pressure of ice may cause deformations. The strength of material against frost depends on its degree of saturation (it should be under 80%).



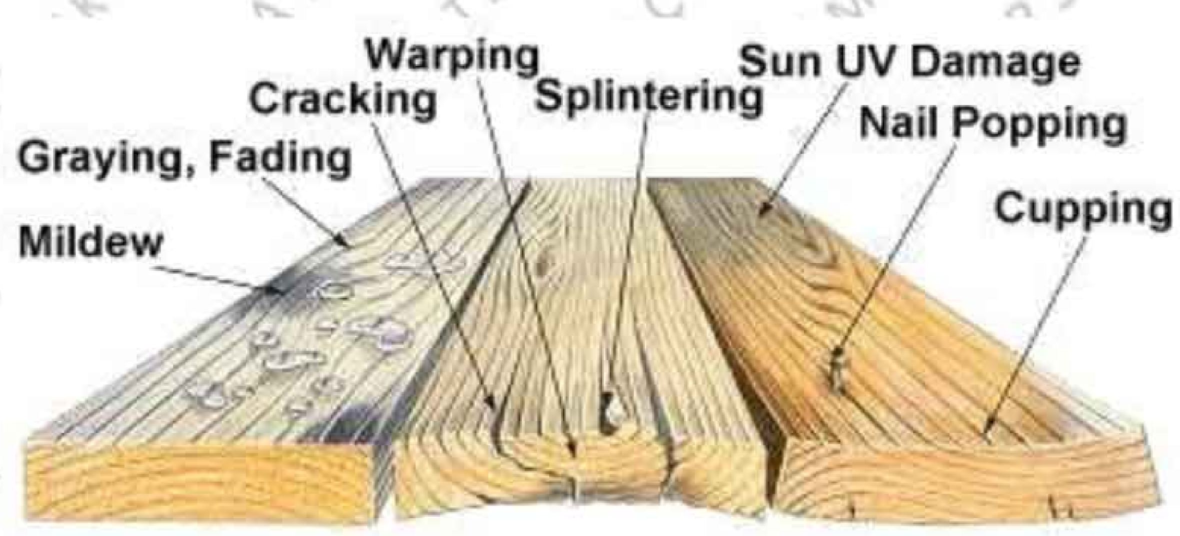
capillarity (hydroscopicity) is the ability of a material absorbing water molecules from the surrounding environment without the assistance of , or even in opposition to external forces like gravity. It occurs because of intermolecular forces between the liquid and surrounding solid surfaces, a combination of surface tension and adhesive forces between the liquid and solid.



diffusion resistance (μ) is the factor showing the vapor permeability of a material, indicating how many times it will be more difficult to pass the water vapor through the material then through the air.



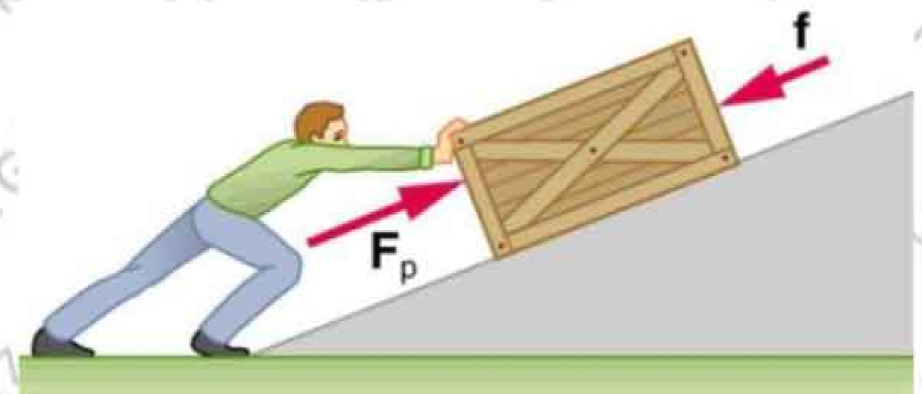
swelling and shrinkage Swelling occurs when the open porous materials absorb water and the volume of materials increase. Shrinkage is the opposite of this, the decrease in the volume of material due to loss bound water.



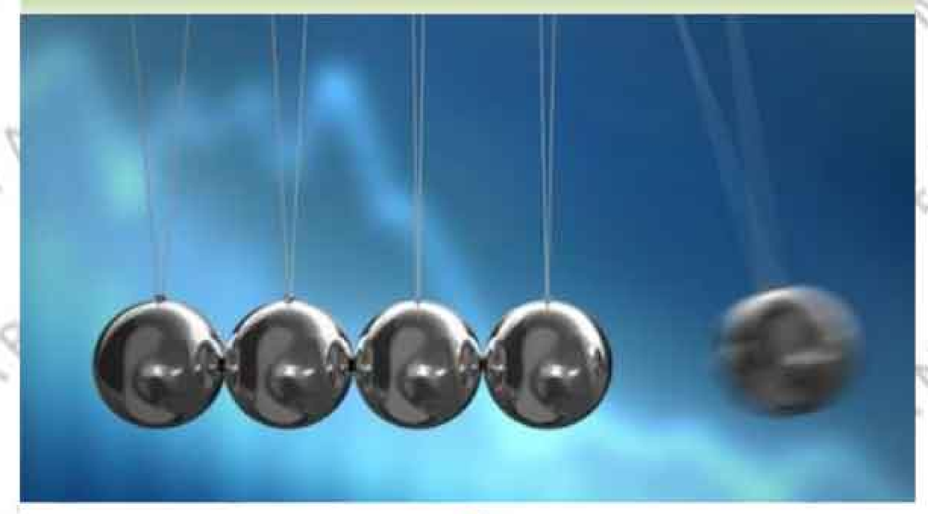
moisture content Is the quantity of water contained in a material and is expressed as a ratio, which can range from 0 (completely dry) to the value of the material's porosity at saturation.

mechanical properties of building products: mechanics is an area of science concerned with the behavior of physical bodies when subjected to forces and displacements. All the deformations under external forces and the resistance of a material against them determine the mechanical properties of materials. In order to explain the mechanical properties, some definitions should be explained.

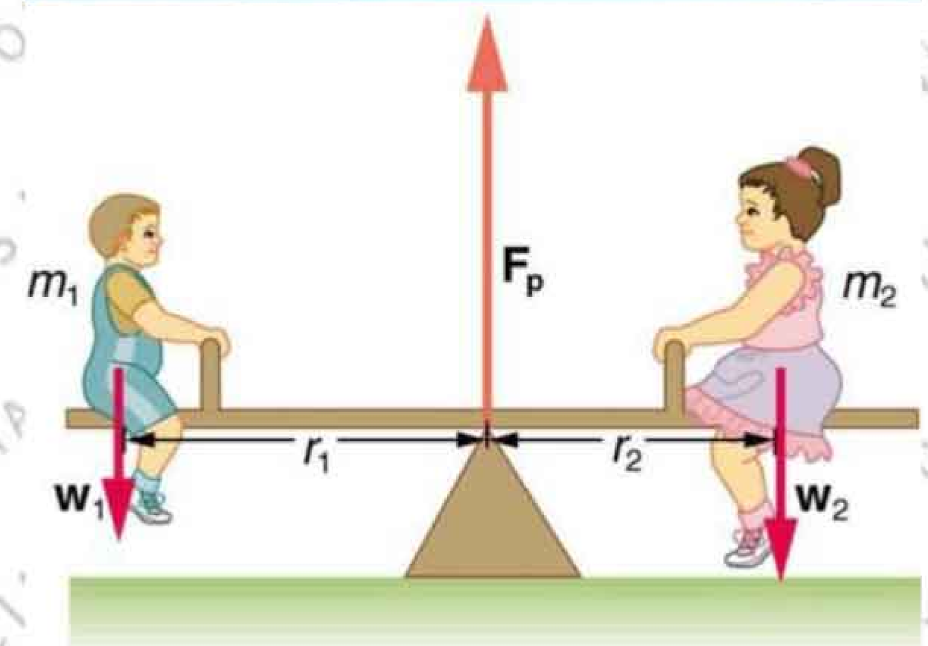
force is any interaction that, when unopposed, will change the motion or shape of an object.



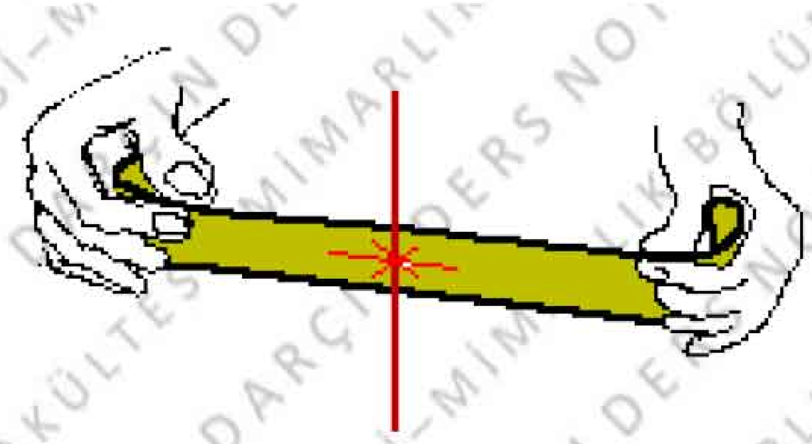
momentum can be defined as "mass in motion". All the objects have mass, so if an object is moving, then it has momentum. Momentum depends upon the variables mass and velocity.



equilibrium An object is in mechanical equilibrium if the net force on that object is zero. When a force is applied on an object, it will make the object move or the object will get to state of equilibrium by the applied force eliminating previously active force on the object.

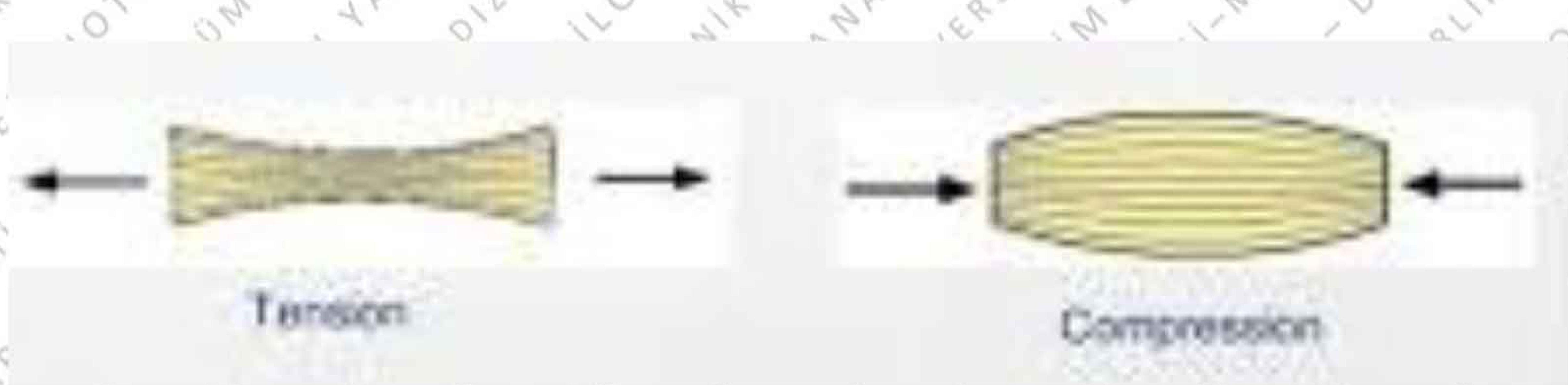


stress In mechanics, stress is a physical quantity that expresses the internal forces that neighboring particles of a continuous material exert on each other. According to the direction of force, there will be compressive or tensile stress in materials.



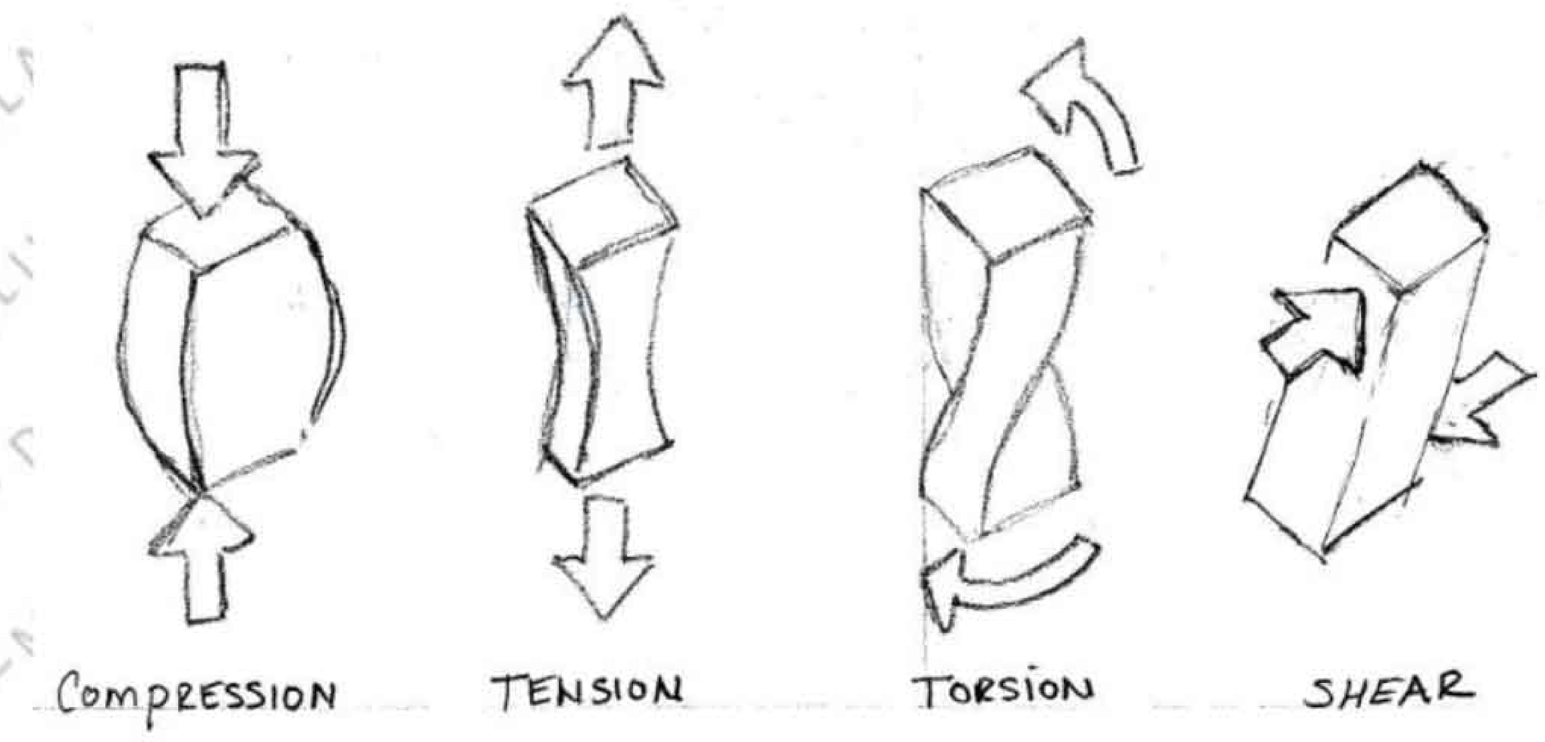
compressive and tensile strength Compressive stress appears when the material is under compression, external forces are applied towards the center of material which leads it to a smaller volume by decreasing the gaps between atoms. Tensile stress is the opposite of this, appears when the external forces are applied from the center towards outside, which leads it to a bigger volume by increasing the gaps between atoms. If the force is increased, after a certain point, the microstructure of material will begin to change.

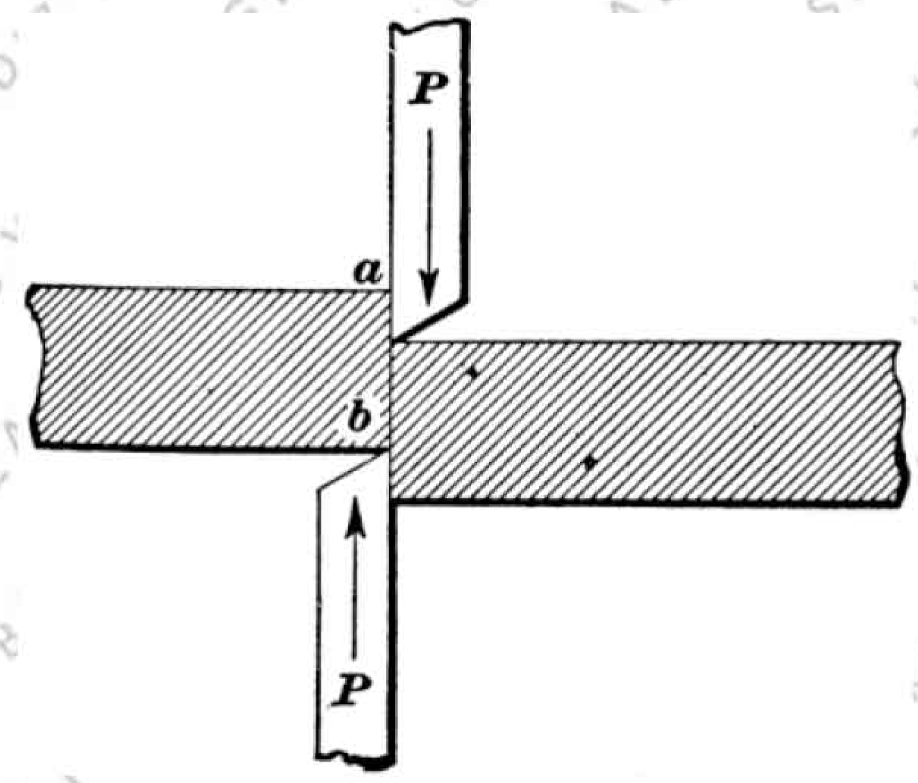
Compressive and tensile strength of a material are the maximum stress this material can withstand without a permanent deformation.



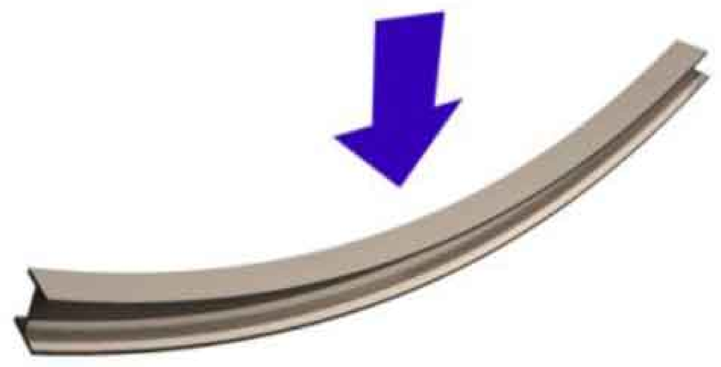
shear strength A shear stress appears when a force which tends to produce a sliding failure on a material along a plane that is parallel to the direction of the force. If the force vector is perpendicular to the material's cross section, it will cause a compressive or tensile stress according to the direction of the vector. If the force vector is parallel to the material's cross section, it will cause a shear stress.

Shear strength is the strength of material against type of deformation or structural failure where the material or component fails in shear (when a paper is cut with scissors, the paper fails in shear).

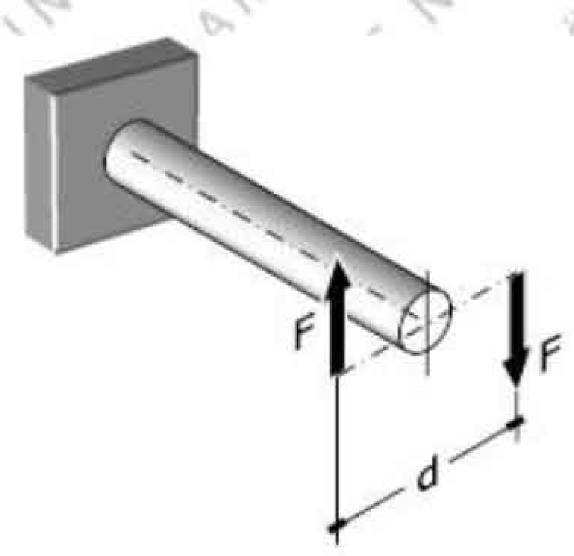




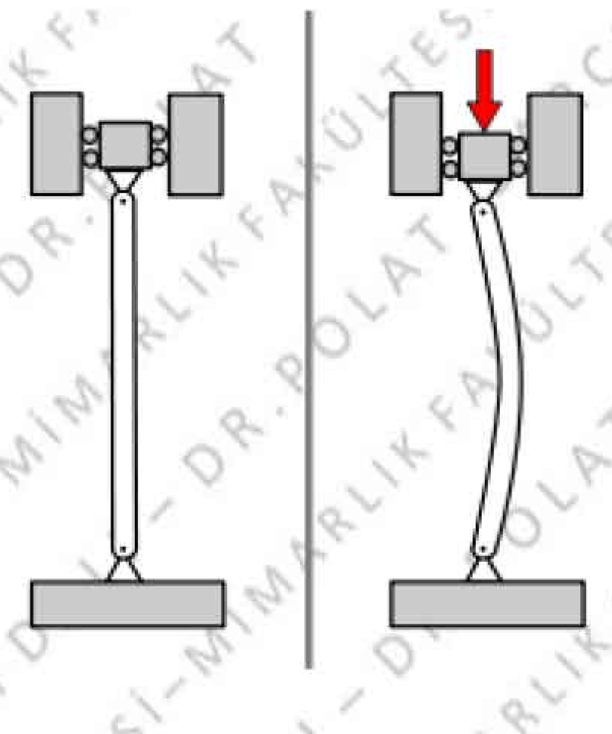
bending (flexure) strength Bending characterizes the behavior of a slender product subjected to an external load applied perpendicularly to a longitudinal axis of the product. In the side of the product subjected to the force will be under compression, whereas other side will experience tensile.



torsional strength Torsion is the twisting of an object due to an applied torque, two forces in opposite directions applied perpendicularly to the axis of material. With torsion, there usually appears bending and shearing stress together.

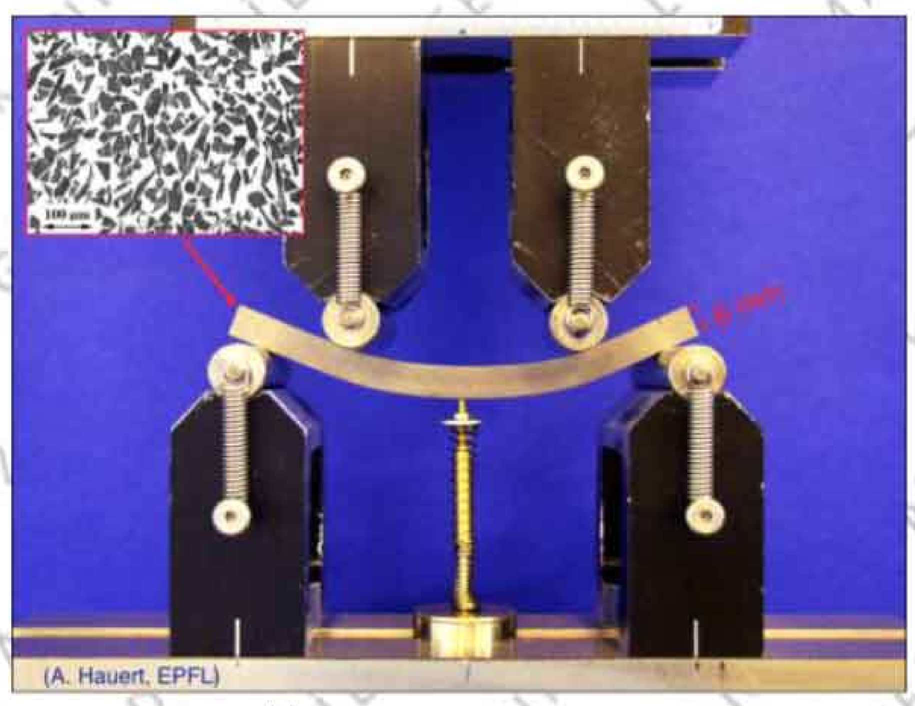


buckling strength When long products with narrow cross sections compared to its length are under compressive stress, buckling may occur. Buckling is characterized by a sudden sideways deflection of the product.

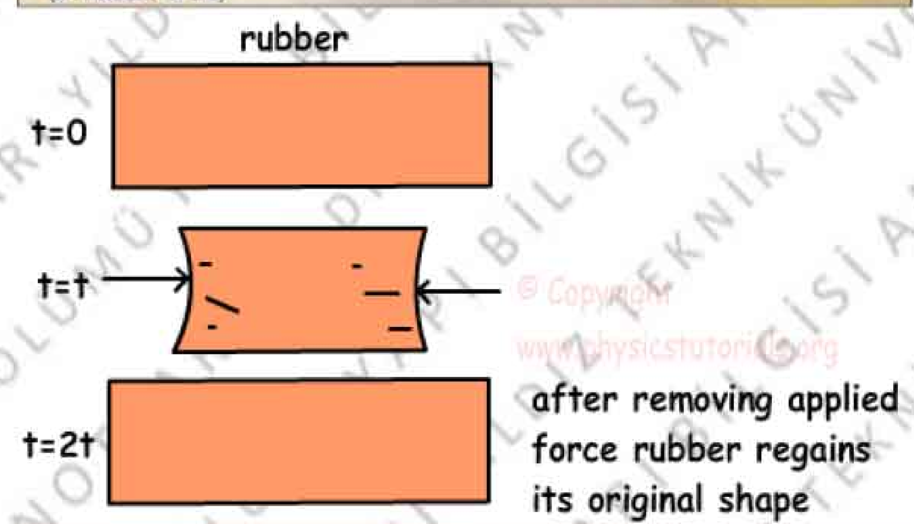


technological properties of building products: Complex properties with values depending on measurement methods are defined technological properties. In order to compare different products according to technological properties, they must be measured using same measurement and experiment methods.

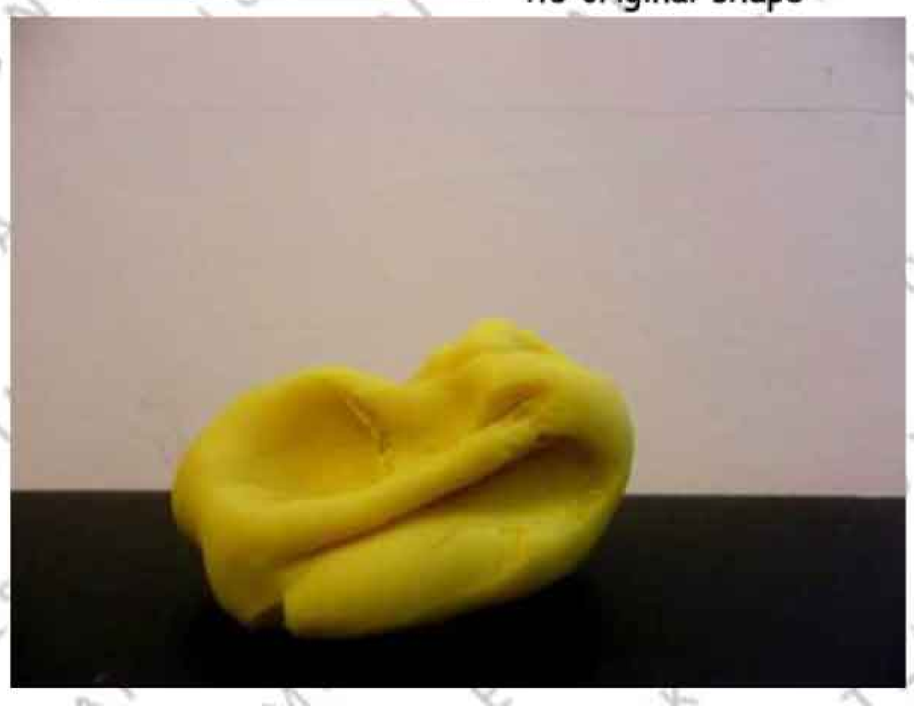
deformation If any applied force to a product causes some changes in its microstructure (changes the properties of bonds between molecules and atoms) that results any change in the form of the product, this situation can be defined as deformation. According to the deformation types materials can be classified as elastic, plastic and elasto-plastic materials.



elasticity is the ability of a material to deform under a deforming force, resist to it and to return to its original size and shape when the force is removed.

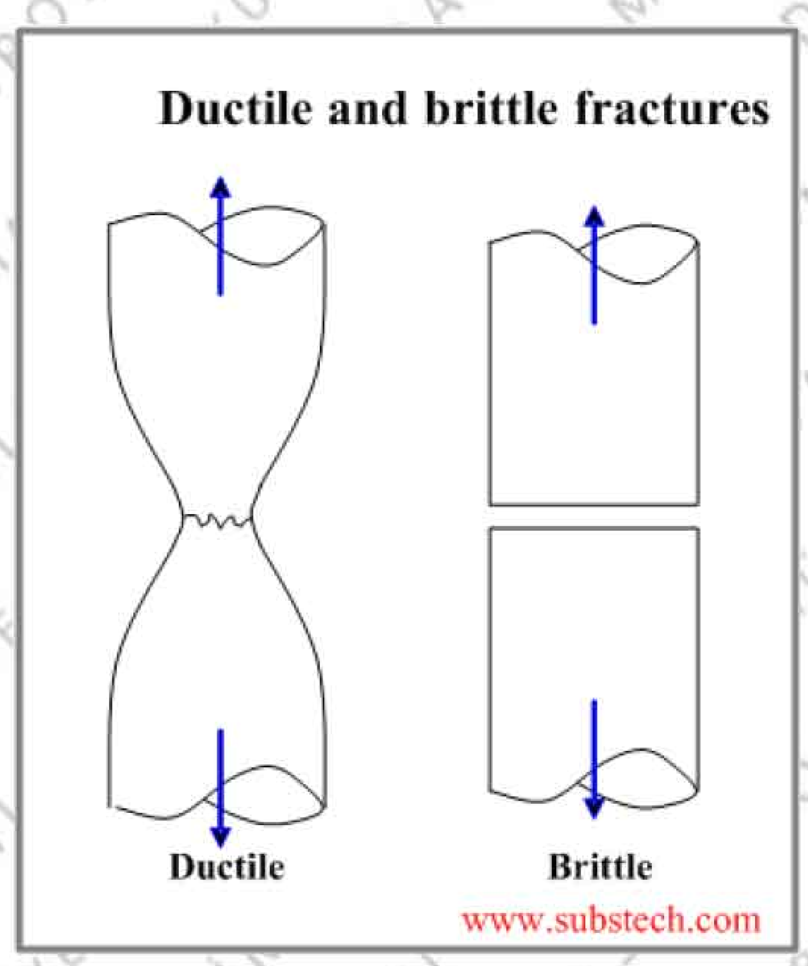


plasticity is the propensity of a material to undergo permanent deformation even after the force is removed.



elasto-plasticity is the condition of showing both elastic and plastic properties, deforming under a force and partially returning to its original shape after the force is removed.

fracture (breaking) strength Fracture is the separation of a material into two or more pieces under the action of stress. Materials failing via fracture under compressive stress are called **brittle materials**. Opposite to this, **ductile materials** have the ability to deform and stretch before reaching its limit of elasticity. In brittle fracture, no apparent plastic deformation takes place, whereas in ductile fracture, extensive plastic deformation occurs before fracture.



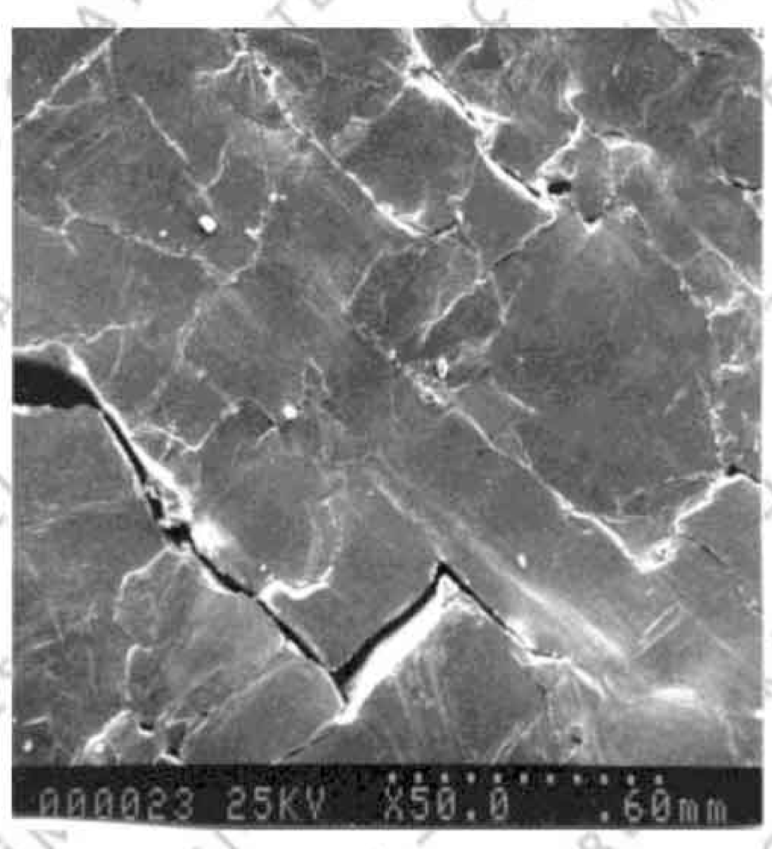
The degree of resistance shown by materials before the fracture happens is called fracture strength.

impact resistance is the ability of a material to withstand a high force applied to it over a short period of time. A high force over a short time has a greater effect then a weaker force over a long period in term of fracture.

stiffness is the rigidity of an object - the extent to which it resists deformation in response to an applied force.

wear resistance Wear is erosion of small particles from the surface of materials under forces according to its stiffness.

fatigue resistance Fatigue is the weakening of a material caused by repeatedly applied loads under its elasticity limit, resulting an early and brittle fracture.



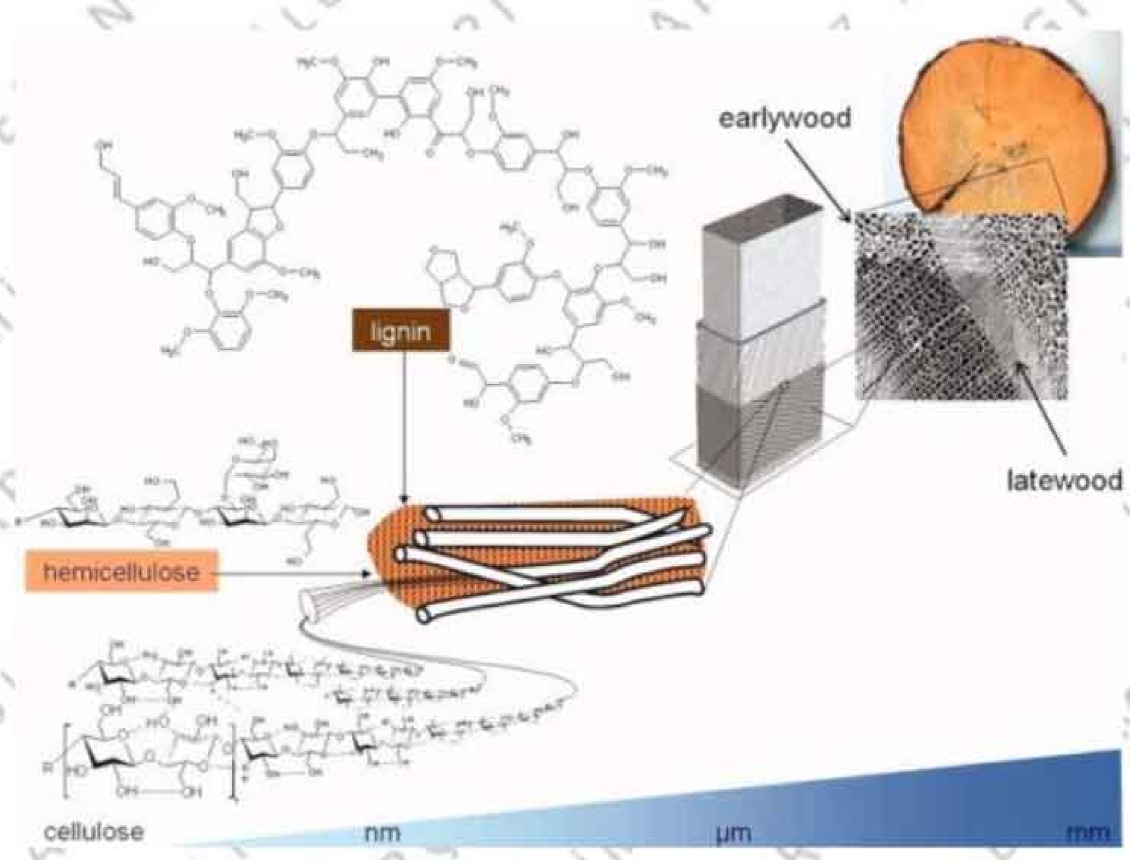
creep (cold flow) stiffness Creep is the tendency of a solid material to deform permanently and increasingly over time under the influence of stress. It can occur as a result of long term exposure to high levels of stress that are still below the yield stress of the material.

stress relaxation Stress relaxation is the observed decrease in stress in response to the same amount of strain generated in the structure. This is primarily due to keeping the structure in a strained condition for some finite interval of time and hence causing some amount of plastic strain taking place of initial elastic strain.

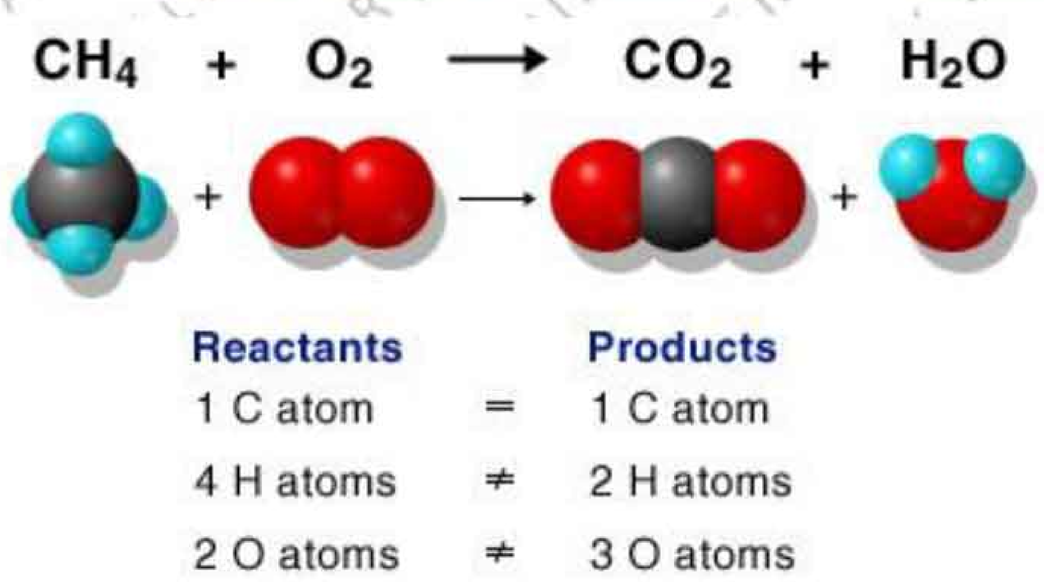
viscosity The viscosity is a measure of amorphous and liquid materials resistance to gradual deformation by shear or tensile stress. The molecular structure of these materials is separated from each other slowly and at a constant rate. This phenomenon is called viscous flow. If the viscosity of a material is high, only if high level of loads are applied for a very long period of time will cause viscous flow, otherwise, these materials just show elastic deformations.

physicochemical properties of building products: Physical chemistry is the study of macroscopic, atomic, subatomic and particulate phenomena in chemical systems in terms of the principles, particles and concepts of physics.

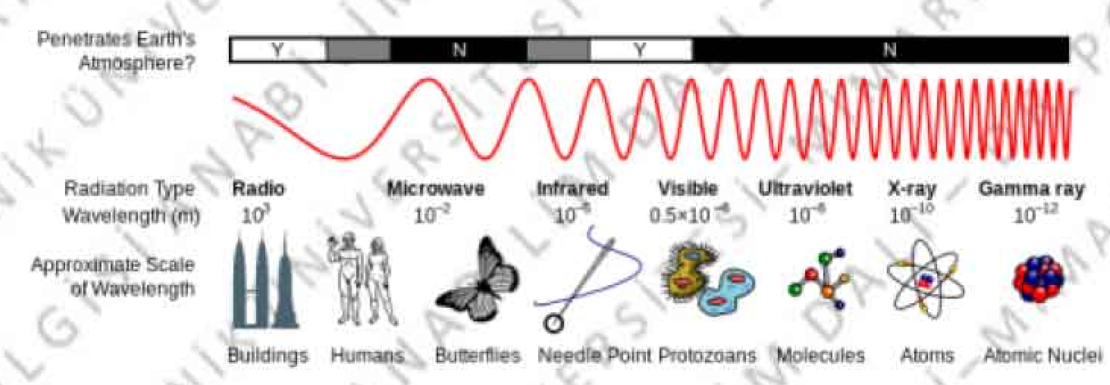
chemical composition of products Because all objects in nature are varied synthesis of 92 elements, the chemical composition of different objects is important in terms of relationships among each other and between different factors such as sun, atmospheric effects, etc with products. According to these relationships, the microstructures and other physical properties of building products may change.



effects of chemicals on building products According to their chemical compositions, building products may be affected from other chemicals causing chemical reactions. A chemical reaction is a process that leads to the transformation of one set of chemical substances to another. Chemical reactions are usually characterized by a chemical change and they yield one or more new substances which usually have properties different from the initial substances. The effects can be direct (effects of acid or base) or indirect (effects of chemical reactions due to contact with air and water).

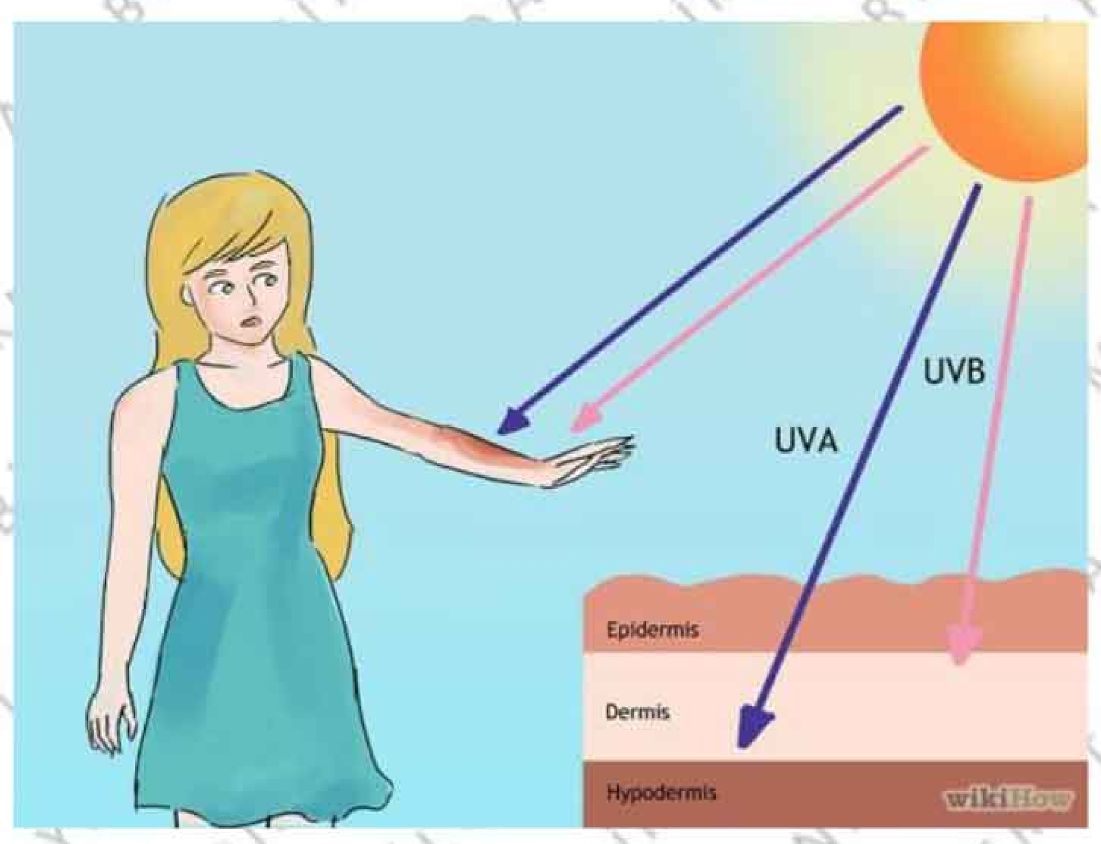


radiation Sunlight is a portion of electromagnetic radiation given off by the sun, in particular infrared, visible and ultraviolet light. Visible spectrum includes parts between purple (380 nm) and red (760 nm) rays. Rays with shorter wavelength are defined as ultraviolet, rays with bigger wavelength are characterized as infrared, both invisible and have different effects.



effects of ultraviolet radiation

The ultraviolet part of spectrum covers the range from 10 nm to 400 nm. Because of short wavelength, the kinetic energy of these rays are high which can cause important disintegration and decomposition on especially organic building products. For instance, UV rays can break cellulose in some natural materials causing color changes, surface fractures and decrease in mechanical strength.

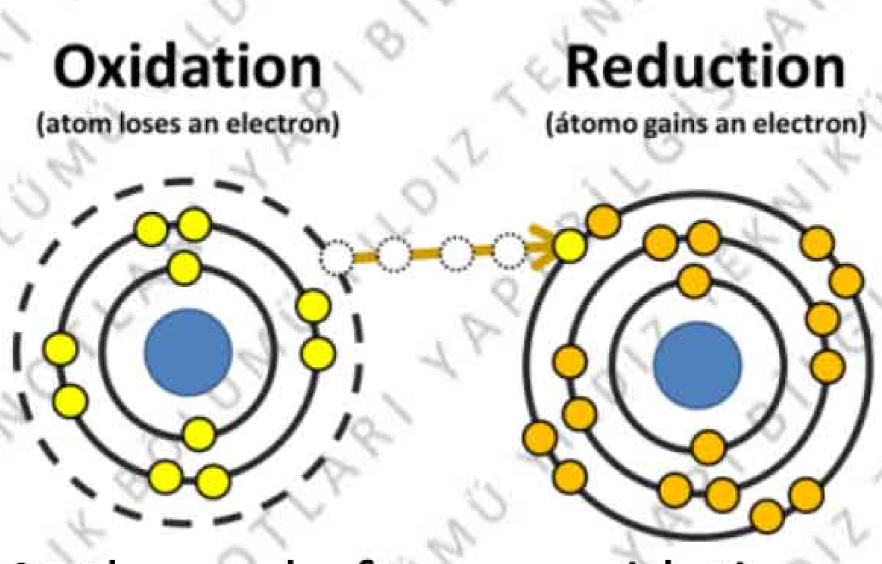


effects of infrared radiation

The infrared part of the spectrum covers the range from roughly 1 mm to 750 nm, rays transferring heat energy. When building products encounters IR radiation, due to increase in heat energy, the temperatures of these products increase as well. According to their physical properties related to heat, products with increasing temperature may conduct heat energy or according to their technological properties, they may deform.

oxidation in building products

A chemical reaction in which the oxidation states of atoms are changed is called redox (short for reduction – oxidation reaction). Any such reaction involves both a reduction process and a complementary oxidation process, two key concepts involved with electron transfer processes, the transfer of electrons between chemical species. Oxidation is the loss of electrons or an increase in oxidation state by a molecule, atom or ion. Reduction is the gain of electrons or a decrease in oxidation state by a molecule, atom or ion. Reaction can occur relatively slowly as in the case of rust or more quickly as in the case of fire (during the combustion of wood, oxygen from the air is reduced transferring electrons from the carbon).



At the end of some oxidation processes, a new layer is formed on the surface of building products. If this layer has a porous and loose structre, it may destruct the structure of the product. If the layer is non-porous, it protects the main structure of the product. The most common example is the oxidation of metals forming rust or patina in different colors on the surface. Rust is an oxide formed by the redox reaction of iron and oxygen in the presence of water or humidity. Patina is a thin layer that variously forms on the surface of copper, bronze and similar metals as a coating of various chemical compounds such as oxides formed on the surface during exposure to oxygen, rain, carbondioxide, etc.


iron oxide


patina on copper

corrosion

Corrosion is a natural process, which converts a refined metal to a more chemically stable form, such as its oxide; electrochemical oxidation of metal in reaction with an oxidant such as oxygen. It is the gradual destruction of materials (usually metals) by chemical and / or electrochemical reaction with their environment. Rusting, the formation of iron oxides is a well known example of electrochemical corrosion. This type of damage typically produces oxides or salts of the original metal and results in a distinctive orange coloration. Corrosion degrades the useful properties of materials and structures including strength, appearance and permeability to liquids and gases.

Corrosion is either uniform (metal corrodes at the same rate over the entire surface) or it is localized (in which case only small areas are affected). Some types based on appearance of the corroded metal are:

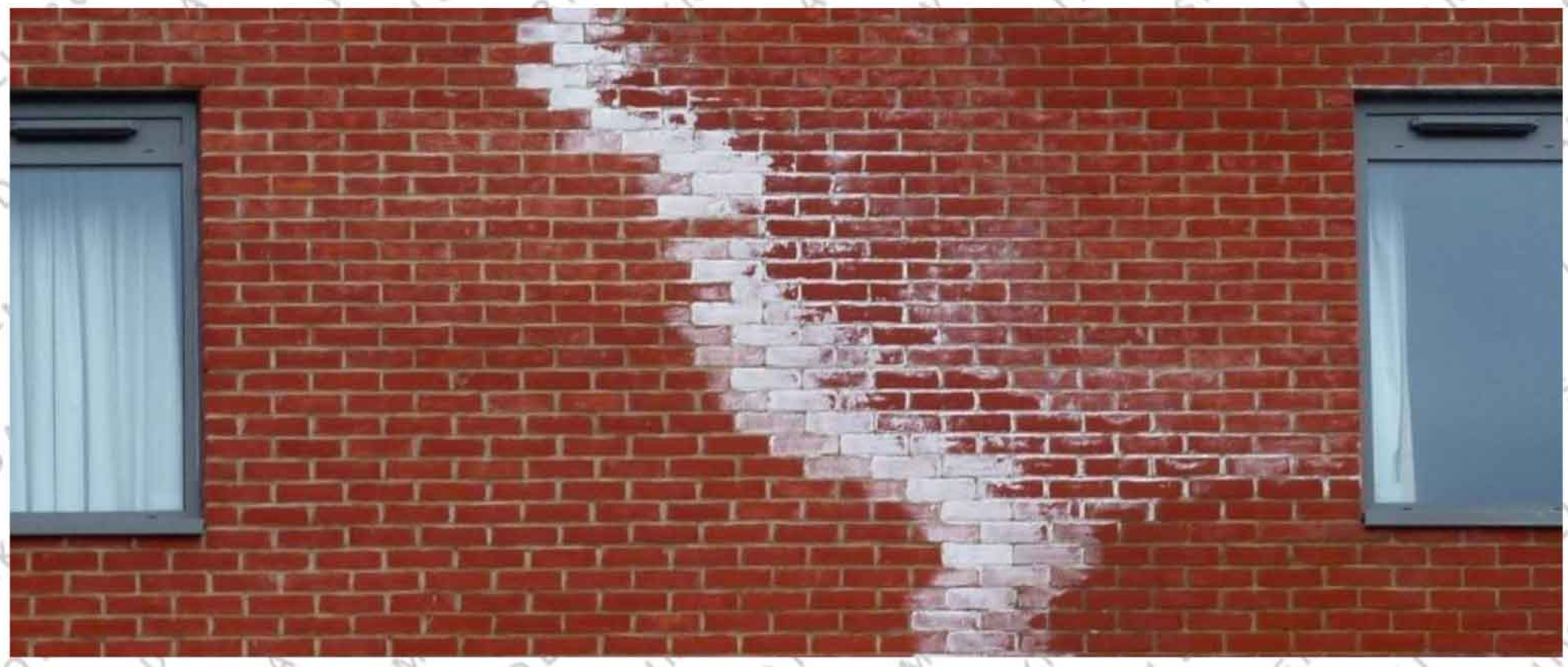
- pitting (creation of small holes in the metal)

- lamellar (proceeds from initiation sites along planes parallel to the surface)

effects of water and humidity on building products

Water and humidity can change the physical and mechanical properties of some materials or may form new chemical compounds (e.g. combination of water with dry plaster powder forms gypsum).

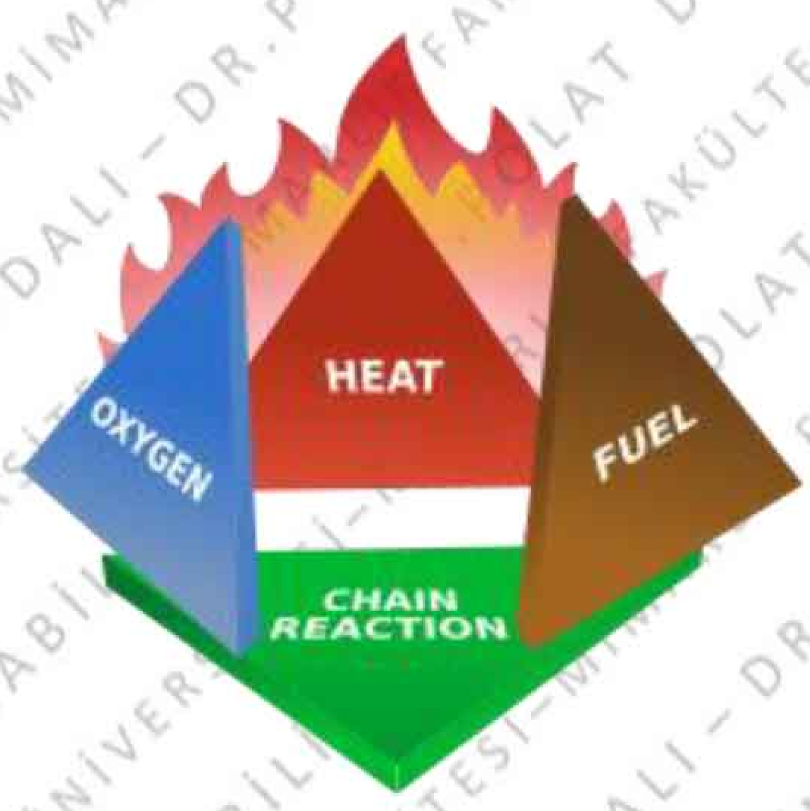
Water becomes acidic by dispersing carbon dioxide in the atmosphere. Many building products have alkaline properties. Because of this reason, acidic water may have chemical reactions with these products. When the water migrates to the surface of porous products and evaporates, a coating of salt will be left. This phenomenon is called efflorescence.



effects of organisms Organisms may harm especially organic products by causing chemical reactions. Molds, bacteria, worms, etc. decompose organic products. For instance, wood can be decomposed into starch and cellulose and becomes dust.

fire Fire is the rapid oxidation of a material in the exothermic chemical process of combustion, releasing heat, light and various reaction products such as gases and particles. Heat is due to conversion of the weak double bond in molecular oxygen (O_2) to the stronger bonds in the combustion products carbon dioxide and water releases energy. At a certain point in the combustion reaction, called the ignition point, flames are produced. The flame is the visible portion of the fire.

Fire start when an inflammable or a combustible material, in combination with a sufficient quantity of an oxidizer such as oxygen gas or another oxygen rich compound, is exposed to a source of heat or ambient temperature above flash point for the fuel / oxidizer mix and is able to sustain a rate of rapid oxidation that produces a chain reaction. Fire cannot exist without all of these elements in place and in the right proportions.



combustibility of building products

When an inflammable product is ignited, it tends to ignite other inflammable products in the same space, the fire tends to expand. If it is not controlled and extinguished, it starts to affect the walls and floors and expands to other units through openings or may cause inflammation of other products by increasing the temperature in the neighbor units. This phenomenon depends on the combustibility of building products.

Combustibility is a measure of how easily a substance will set on fire, through fire or combustion. A non-combustible material is a substance that will not ignite, burn, support combustion or release flammable vapors when subject to fire or heat. Flammability is the ability of a substance to burn or ignite, causing fire or combustion. The degree of difficulty required to cause the combustion of a substance is quantified through fire testing.

combustibility	**production of smoke**	**flaming droplets / particles**	**TS EN 16501-1 classification**	**DIN 4102 classification**
non-combustible (hiç yanmaz)	-	-	A1	A1
hardly combustible (zor yanıcı)	-	-	A2 – S1, d0	A2
hardly flammable (zor alevlenici)	-	-	B – S1, d0	B1
			C – S1, d0	
	+	-	A2 – S2, d0	
			A2 – S3, d0	
			B – S2, d0	
			B – S3, d0	
			C – S2, d0	
			C – S3, d0	
	-	+	A2 – S1, d1	
			A2 – S1, d2	
			B – S1, d1	
			B – S1, d2	
			C – S1, d1	
			C – S1, d2	
	+	+	A2 – S3, d2	
			B – S3, d2	
			C – S3, d2	
normal flammable (normal alevlenici)	+	-	D – S1, d0	B2
			D – S2, d0	
			D – S3, d0	
			E	
	+	+	D – S1, d1	
			D – S2, d1	
			D – S3, d1	
			D – S1, d2	
			D – S2, d2	
			D – S3, d2	
	+	+	E – d2	
easily flammable (kolay alevlenici)	+	+	F	B3

euroclass	**contribution to fire**
A1	non combustible
A2	limited combustible – no flashover
B	no flashover
C	flashover after 10 min.
D	flashover before 10 min.
E	flashover before 2 min.
F	no performance determined

class	**according to the amount of smoke produced in the first 10 min. the total smoke production (TSP) and smoke growth rate (SMOGRA)**
S1	SMOGRA ≤ $30m^2/s^2$ and TSP600s ≤ $50m^2$
S2	SMOGRA ≤ $180m^2/s^2$ and TLS 600s ≤ $200m^2$
S3	not S1 or S2
class	**according to the existence of flaming droplets / particles in the first 10 min. and the flaming time of droplets more than 10 sec.**
d0	no flaming droplets / particles in 600 sec. according to EN 13823
d1	Flaming droplets no longer than 10 sec. İn 600 sec. according to EN 13823
d2	not d0 or d1

fire resistance rating A fire resistance rating typically means the duration for which a passive fire protection system can withstand a standard fire resistance test. This can be quantified simply as a measure of time or it may entail a host of other criteria.

F30 resisting for 30 min.

F60 resisting for 60 min

F90 resisting for 90 min.

F120 resisting for 120 min.

F180 resisting for 180 min.

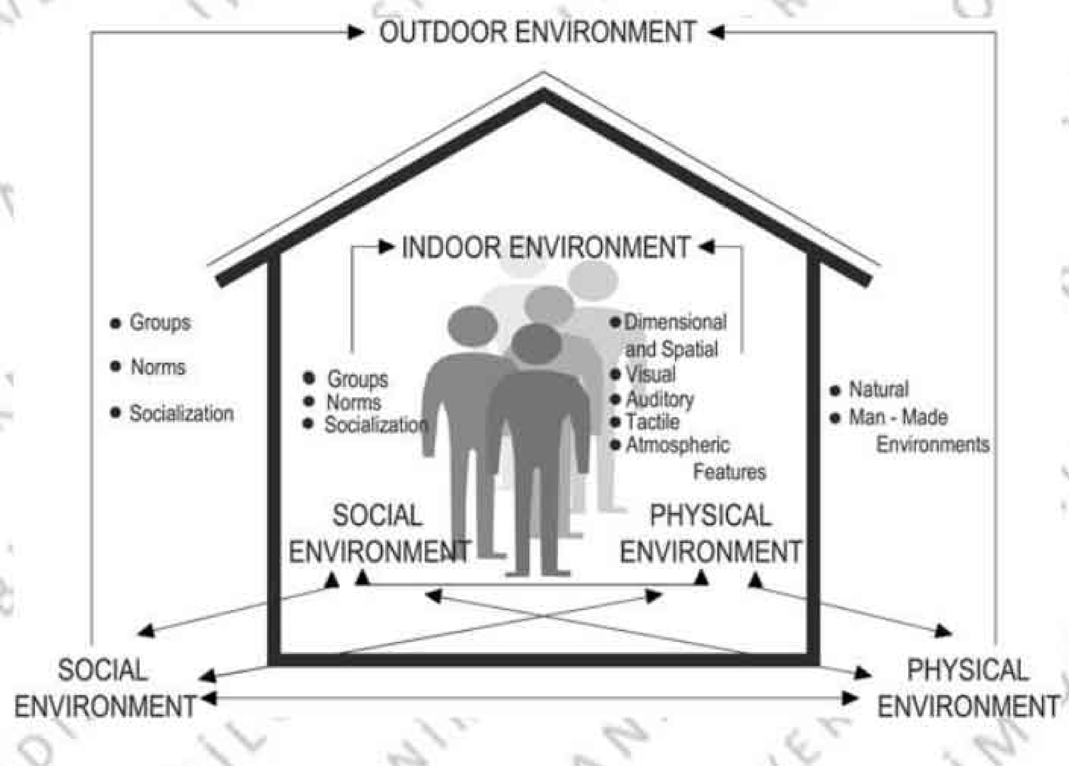
producing harmful gases during fire Because of the chemical reactions during the fire, the molecular structure of some products is destructed and some harmful gases are produced. The main death cause during a fire is smoke and toxic gases (75%). Based on this statement, for the decisions of building products, it should be questioned if the product may cause production of harmful gases during fire.

properties of building products related to human health: According to WHO, health is not only a state of not having any disease, but also being totally well physically, psychologically and socially. Human health is the most important parameter in context of building and it should not be affected negatively during the production, application, usage and after-use stages of building products. Building products constitute the physical indoor and outdoor environmental properties of the building and they may affect the social environments. According to this, products should not cause building environments have negative features that may procreate negative conditions risking the health of humans.

the physical indoor environment of building

The physical indoor environmental features of the building are (Balanlı, 2011):

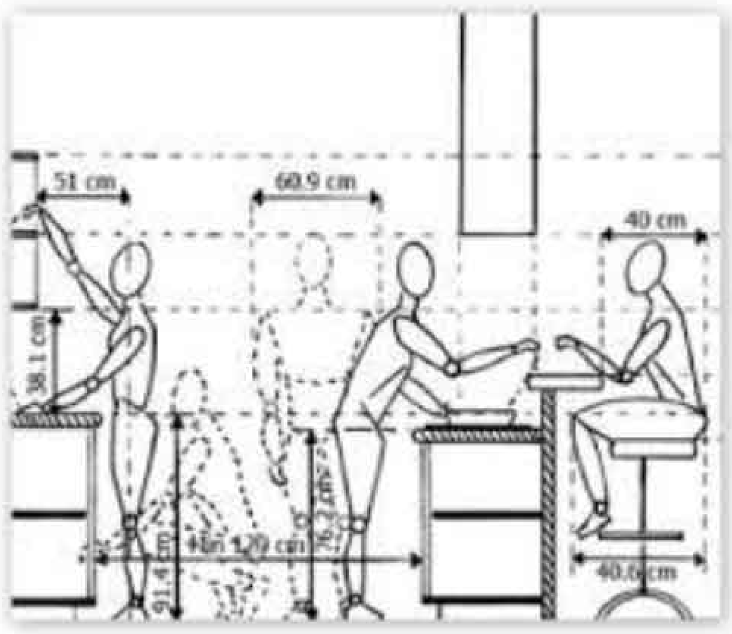
- dimensional and spatial properties,
- visual properties,
- auditory properties,
- tactile properties,
- atmospheric properties.



During the decision process of building products, the physical indoor environmental features of the building should be considered and the products should not create an unhealthy indoor environment.

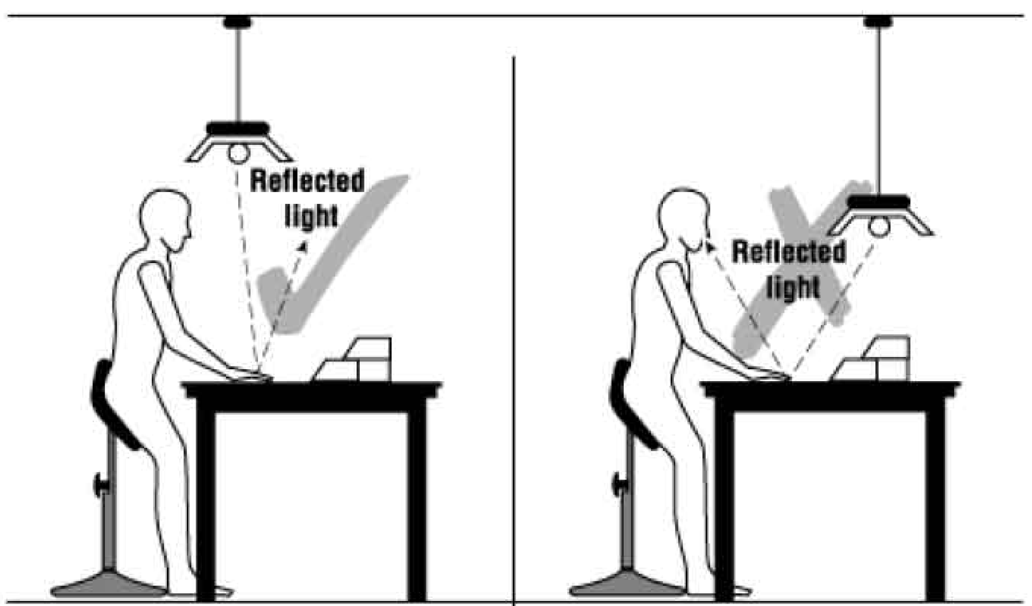
dimensional and spatial properties

If the dimensions of building products are not compatible with the biological properties of the user, many health problems such as musculoskeletal injuries may happen.



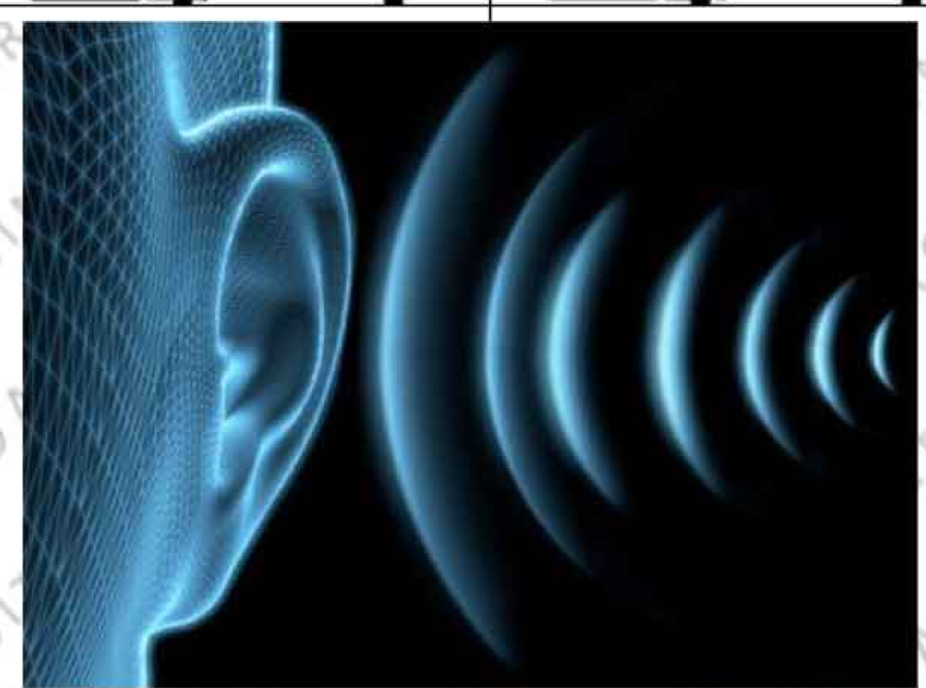
visual properties

If the visual and lighting properties of building are not compatible with the biological properties of the user, health problems such as vision disorders, headaches may happen.



auditory properties

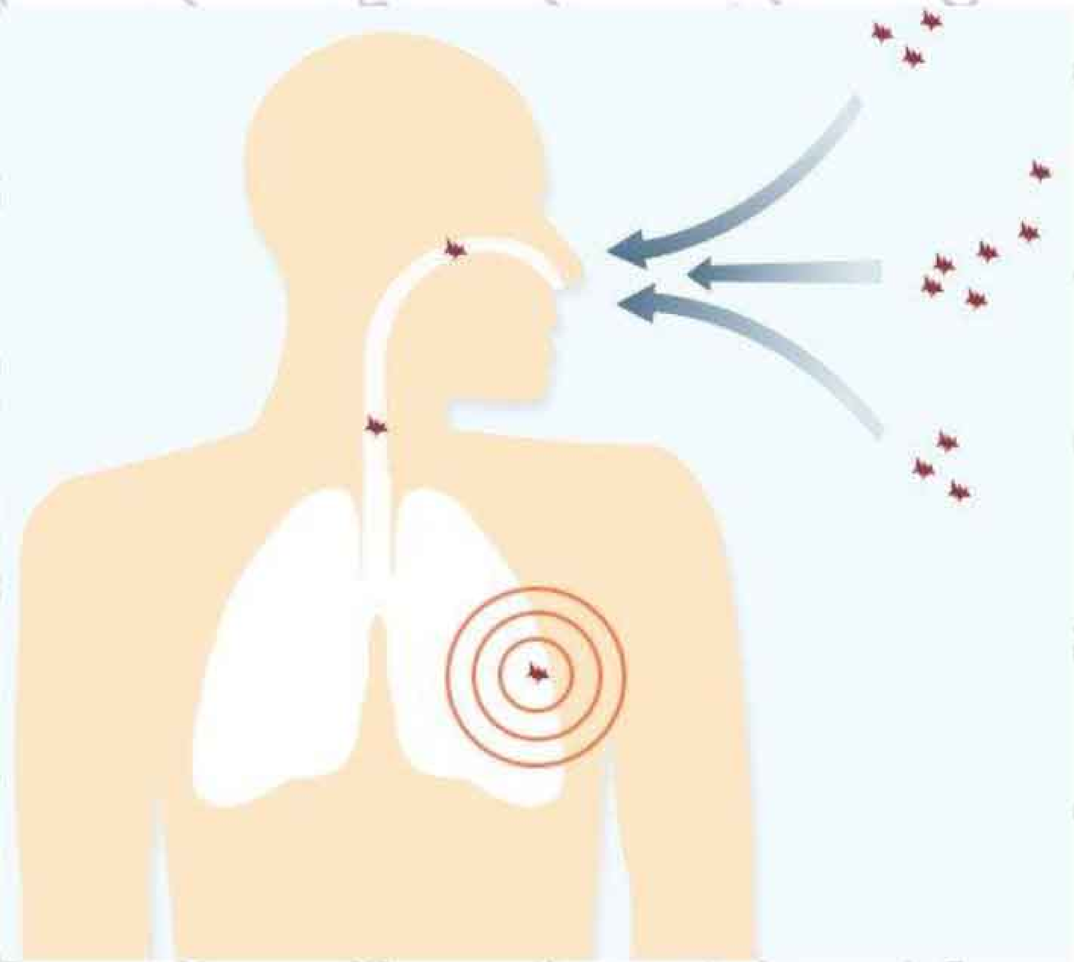
If the auditory properties of building are not compatible with the biological properties of the user, health problems such as hearing loss, acoustic trauma and tinnitus may happen.



tactile properties

If the hardness, roughness, sharpness, temperature, hygiene, etc. of surfaces of building products are not compatible with the user, aches, fractures, ruptures, wounds, etc. may happen.

atmospheric properties If the indoor air contains air pollutants or if the temperature, humidity, flow rate and electromagnetic properties of the air are not compatible with the user, many health problems such as cancer, headache, stuffy nose, sore throat, etc. may happen.



properties of building products related to usage: These properties include features of building products which are effective mostly during usage stage of the building.

cleanability Building products should be cleanable, should not gather dust, host bacteria or any other harmful organisms.

reparability Building products should be easily maintained and repaired during the usage stage.

useful life time and after use stage One of the criteria for selecting building products is the lifetime of products. Their useful life should be long and compatible with the life of the building. In the after use stage, building products should be reused or recycled without damaging the nature.

properties of building products related to production and application: These properties include features of building products starting with their production till their application in the construction process.

lead time This is the latency between the initiation and execution of the process of producing a building product, including the time to ship from the supplier.

means of transport Transportation of building products from the production area to construction site includes air, rail, road and water. Especially the distance between the production area with construction site, the size of building products and special requirements in order to carry them safely should be considered.

storage conditions of building products If the building products must be delivered before their application, the storage conditions should be considered. According to the properties of materials (such as dimensions, required heat and humidity conditions, fire hazards, etc.) a suitable storage area should be prepared.

ease of assembly Building products may require special equipment of skills during application in terms of grasping, moving, orientation and insertion.

financial properties of building products: Like in all the production processes, cost is the value of money that has been used to produce a building, including all the expenses during the whole production process. Costs related to building products are production, transportation, storage, application, usage and maintenance – repair costs.