Brick

Description

Image



Caption

1. Clay's texture © Diego Torres Silvestre at flickr (CC BY-SA 2.0) 2. Brick wall © Diggersstory at Pixabay [Public domain] 3. Brickwork © Ryan McGuire at Pixabay [Public domain]

The material

Brick is as old as Babylon (4000 BC) and as durable. It is the most ancient of all man-made building materials. The regularity and proportions of bricks makes them easy to lay in a variety of patterns, and their durability makes them an ideal material for the construction of building. Clay - the raw material from which brick are made - is available almost everywhere; finding the energy to fire them can be more of a problem. Pure clay is gray-white in color; the red color of most bricks comes from impurities of iron oxide.

General properties

Density		99.9	-	131	lb/ft^3
Price	*	0.281	-	0.753	USD/lb
Date first used		-7500			

Mechanical properties

Young's modulus		2.18	-	4.35	10^6 psi
Shear modulus		0.87	-	1.81	10^6 psi
Bulk modulus	*	1.16	-	2.47	10^6 psi
Poisson's ratio		0.2	-	0.25	
Yield strength (elastic limit)		0.725	-	2.03	ksi
Tensile strength		0.725	-	2.03	ksi
Compressive strength		1.45	-	10.2	ksi
Elongation		0			% strain
Hardness - Vickers		20	-	35	HV
Fatigue strength at 10^7 cycles	*	0.87	-	1.31	ksi
Fracture toughness		0.91	-	1.82	ksi.in^0.5
Mechanical loss coefficient (tan delta)	*	0.004	-	0.02	

Thermal properties

Melting point	1.7e3	-	2.24e3	°F
Maximum service temperature	1.7e3	-	2.24e3	°F
Minimum service temperature	-460			°F
Thermal conductor or insulator?	Poor insulator			
Thermal conductivity	0.266	-	0.422	BTU.ft/h.ft^2.F
Specific heat capacity	0.179	-	0.203	BTU/lb.°F
Thermal expansion coefficient	2.78	-	4.44	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	1e14	-	3e16	µohm.cm
Dielectric constant (relative permittivity)	7	-	10	
Dissipation factor (dielectric loss tangent)	0.001	-	0.01	
Dielectric strength (dielectric breakdown)	229	-	381	V/mil

Optical properties

Transparency	Opaque

Critical Materials Risk

High critical material risk?	No

Processability

Moldability	2	-	4
Machinability	1	-	2

Durability: water and aqueous solutions

Water (fresh)	Excellent
Water (salt)	Excellent
Soils, acidic (peat)	Excellent
Soils, alkaline (clay)	Excellent
Wine	Excellent

Durability: acids

Acetic acid (10%)	Excellent
Acetic acid (glacial)	Excellent
Citric acid (10%)	Excellent
Hydrochloric acid (10%)	Excellent
Hydrochloric acid (36%)	Excellent
Hydrofluoric acid (40%)	Unacceptable
Nitric acid (10%)	Excellent

Nitric acid (70%)	Excellent
Phosphoric acid (10%)	Excellent
Phosphoric acid (85%)	Excellent
Sulfuric acid (10%)	Excellent
Sulfuric acid (70%)	Excellent

Durability: alkalis

Sodium hydroxide (10%)	Excellent
Sodium hydroxide (60%)	Excellent

Durability: fuels, oils and solvents

Amyl acetate	Excellent
Benzene	Excellent
Carbon tetrachloride	Excellent
Chloroform	Excellent
Crude oil	Excellent
Diesel oil	Excellent
Lubricating oil	Excellent
Paraffin oil (kerosene)	Excellent
Petrol (gasoline)	Excellent
Silicone fluids	Excellent
Toluene	Excellent
Turpentine	Excellent
Vegetable oils (general)	Excellent
White spirit	Excellent

Durability: alcohols, aldehydes, ketones

Acetaldehyde	Excellent
Acetone	Excellent
Ethyl alcohol (ethanol)	Excellent
Ethylene glycol	Excellent
Formaldehyde (40%)	Excellent
Glycerol	Excellent
Methyl alcohol (methanol)	Excellent

Durability: halogens and gases

Chlorine gas (dry)	Excellent
Fluorine (gas)	Limited use
O2 (oxygen gas)	Excellent
Sulfur dioxide (gas)	Excellent

Durability: built environments

Industrial atmosphere	Acceptable
Rural atmosphere	Excellent
Marine atmosphere	Excellent
UV radiation (sunlight)	Excellent

Durability: flammability

Flammability	Non-flammable

Durability: thermal environments

Tolerance to cryogenic temperatures	Excellent
Tolerance up to 150 C (302 F)	Excellent
Tolerance up to 250 C (482 F)	Excellent
Tolerance up to 450 C (842 F)	Excellent
Tolerance up to 850 C (1562 F)	Excellent
Tolerance above 850 C (1562 F)	Excellent

Geo-economic data for principal component

Annual world production, principal component	*	4.92e7	-	5.02e7	ton/yr

Primary material production: energy, CO2 and water

Embodied energy, primary production		238	-	542	kcal/lb
CO2 footprint, primary production		0.206	-	0.227	lb/lb
Water usage	*	0.631	-	0.699	gal(US)/lb
Eco-indicator 95		28			millipoints/kg
Eco-indicator 99		11			millipoints/kg

Material processing: energy

Grinding energy (per unit wt removed)	*	1.05e3	-	1.16e3	kcal/lb

Material processing: CO2 footprint

Grinding CO2 (per unit wt removed)	*	0.727	-	0.804	lb/lb

Material recycling: energy, CO2 and recycle fraction

Recycle	✗			
Recycle fraction in current supply	15	-	20	%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✓			
Biodegrade	✗			
Toxicity rating	Non-toxic			
A renewable resource?	✗			

Environmental notes

Brick is used on a vast scale. The long firing time, extending to some days, involves a considerable consumption of energy, but otherwise the process of making brick is not a damaging one. In use, brick is inert and - particularly if glazed - resists weathering, giving an extremely long life, and they can be reused when a building is demolished.

Supporting information

Design guidelines

Bricks and the mortar used to bond them are strong in compression but weak in tension. This largely determines the way they are used: brick structures (like those of stone) are designed in such a way that the loads are compressive everywhere, ruling out cantilevered or very slender forms. The face of brick can be molded and glazed, allowing great freedom of decoration, and the pattern and natural color variation gives a visually attractive surface. Low -fired, unglazed brick is vulnerable to water-penetration and degradation, and should be screened from direct weathering. High-fired or glazed brick is extremely durable.

Technical notes

Brick is fired clay: hydrous aluminum silicate, with impurities of potash, soda, lime, and oxides of iron. On heating to 900-1200C, the aluminum silicate reacts with soda to form a viscous glass - it is this that bonds the brick together. Most brick is porous; if it is to resist water it is glazed. To do this the surface of the fired brick is painted with a mixture of glass-forming fluxes and the brick is re-fired, melting the glaze, and forming a glassy surface that can be colored.

Typical uses

Domestic and industrial building, walls, paths and roads.

Links

Reference

ProcessUniverse

Producers