Description

Image

Caption

1. Close-up of the material. © Granta Design 2. Slate is used as a roof and wall covering as well as for construction. © Granta Design

The material

Slates are formed by the deposition of clay and mud, consolidated by pressure. Their most striking features are their ability to be cleaved, producing flat slabs or sheets, and their impermeability to water in a direction normal to the cleavage plain. Because of this, slate has been used for centuries for roof tiles, pavings and floors when laid directly on bare earth. Slate is exceptionally durable and weather resistant: if maintained, slate roofs last for hundreds of years. The fine texture and uniform subdued coloring leads also to the decorative use of slate, in stair treads, signs and grave stones.

Composition (summary)

Slate is a form of shale, a complex alumino-silicate.

General properties

Density		2.6e3	- 2.9e3	kg/m^3
Price	*	0.68	- 0.89	USD/kg
Date first used		-10000		

Mechanical properties

Young's modulus		60	- 90	GPa
Shear modulus	*	20	- 30	GPa
Bulk modulus	*	50	- 80	GPa
Poisson's ratio	*	0.22	- 0.3	
Yield strength (elastic limit)	*	15	- 30	MPa
Tensile strength	*	15	- 30	MPa
Compressive strength		120	- 175	MPa
Elongation		0		% strain
Hardness - Vickers		22	- 60	HV

Fatigue strength at 10^7 cycles	* 10	-	12	MPa
Fracture toughness	* 0.4	-	1.1	MPa.m^0.5
Mechanical loss coefficient (tan delta)	* 0.001	-	0.003	

Thermal properties

Maximum service temperature	* 350	-	500	°C
Minimum service temperature	-50	-	-30	°C
Thermal conductor or insulator?	Poor insulator			
Thermal conductivity	1.2	-	2.1	W/m.°C
Specific heat capacity	850	-	890	J/kg.°C
Thermal expansion coefficient	10	-	12	µstrain/°C

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	* 1e12	-	1e14	µohm.cm
Dielectric constant (relative permittivity)	* 8	-	15	
Dissipation factor (dielectric loss tangent)	* 0.001	-	0.005	
Dielectric strength (dielectric breakdown)	* 5	-	12	1000000 V/m

Optical properties

Transparency	Opaque

Critical Materials Risk

High critical material risk?	No

Processability

Machinability	3	-	4	

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)	Acceptable
O2 (oxygen gas)	Excellent
Sulfur dioxide (gas)	Excellent

Durability: built environments

Industrial atmosphere	Excellent
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)	Unacceptable
Tolerance above 850 C (1562 F)	Unacceptable

Primary material production: energy, CO2 and water

Embodied energy, primary production		1.16	-	1.29	MJ/kg
CO2 footprint, primary production		0.0698	-	0.0772	kg/kg
Water usage	*	3.23	-	3.57	l/kg
Eco-indicator 99		34			millipoints/kg

Material processing: energy

Grinding energy (per unit wt removed)	*	10.5	-	11.6	MJ/kg

Material processing: CO2 footprint

Grinding CO2 (per unit wt removed)	*	0.788	-	0.871	kg/kg

Material recycling: energy, CO2 and recycle fraction

Recycle	✗				
Recycle fraction in current supply	*	5	-	10	%
Downcycle	✓				
Combust for energy recovery	✗				
Landfill	✓				
Biodegrade	✗				
Toxicity rating	Non-toxic				
A renewable resource?	✗				

Environmental notes

Slate in bulk is chemically inert and non-toxic. Silicate dust created by cutting causes respiratory damage.

Supporting information

Design guidelines

Slate is an exceptionally stable and inert material. Slate roofs last between 30 and 100 years, depending on the climate. It can be damaged by severe frost.

Technical notes

Slate cleaves easily to give surfaces that can be extremely flat -- its use as the surface of a billiard table is an example. Its fine texture allows delicate incising and carving.

Typical uses

Roof tiles, paving, floors, stair treads, table tops (including billiard and snooker tables), chalk boards, electric panels, gravestones and other monumental signs.

Further reading

Doran, D.K. (ed.) Construction materials reference book, Butterworth Heinemann, Oxford (1992)

Links

Reference

ProcessUniverse

Producers