Plaster of Paris

Description

Image

Caption

1. Decorative ceiling plaster work. © Richerd Needham at en.wikipedia - (CC BY-SA 3.0) 2. Hospital Corpsman applies cast material to the arm of Damage Controlman Fireman. © Class Jason R. Williams, U.S. Navy - Public domain

The material

Plaster of Paris is exactly that: a plaster that, originally, came from Paris, France. It is made by calcining the mineral gypsum, CaSO4.2H2O, at about 180°C, driving off water to give the anhydrite 2CaSO4.H2O. When mixed with water it rehydrates and sets to a hard, white solid. It is used to make molds and casts for ceramics and sculptures, to make pre-cast ornamental plasterwork on ceilings and cornices, and for orthopedic bandages or casts. In medieval and renaissance times gesso (plaster of Paris mixed with glue) was applied to wood panels or canvas as the ground for tempera paintings.

Compositional summary

2CaSO4.H2O, Gypsum

General properties

Density		1.18e3	-	1.8e3	kg/m^3
Price	*	1.45	-	2.07	USD/kg
Date first used		1730			

Mechanical properties

Young's modulus		4.5	-	8	GPa
Shear modulus	*	2	-	5	GPa
Bulk modulus	*	3	-	5.5	GPa
Poisson's ratio		0.25	-	0.3	
Yield strength (elastic limit)	*	1	-	4.5	MPa
Tensile strength	*	1	-	4.5	MPa
Compressive strength		14	-	20	MPa
Elongation		0			% strain

Values marked * are estimates.
No warranty is given for the accuracy of this data

Hardness - Vickers	1	-	3	HV
Fatigue strength at 10^7 cycles	1.7	-	2	MPa
Fracture toughness	0.01	-	0.014	MPa.m^0.5
Mechanical loss coefficient (tan delta)	0.1	-	0.3	

Thermal properties

Melting point	* 300	-	500	°C
Maximum service temperature	110	-	180	°C
Minimum service temperature	-73	-	-23	°C
Thermal conductor or insulator?	Poor insulator			
Thermal conductivity	0.4	-	0.6	W/m.°C
Specific heat capacity	600	-	1e3	J/kg.°C
Thermal expansion coefficient	8	-	10	µstrain/°C

Electrical properties

Electrical conductor or insulator?	Poor insulator			
Electrical resistivity	* 1e8	-	1e10	µohm.cm
Dielectric constant (relative permittivity)	* 5	-	9	
Dissipation factor (dielectric loss tangent)	0.001	-	0.01	
Dielectric strength (dielectric breakdown)	* 2	-	4	1000000 V/m

Optical properties

Transparency	Opaque

Processability

Moldability	4	-	5	

Durability: water and aqueous solutions

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

Durability: acids

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

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

Durability: alkalis

Sodium hydroxide (10%)	Limited use
Sodium hydroxide (60%)	Limited use

Durability: fuels, oils and solvents

Amyl acetate	Excellent
Benzene	Excellent
Carbon tetrachloride	Excellent
Chloroform	Excellent
Crude oil	Unacceptable
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)	Limited use
Fluorine (gas)	Limited use
O2 (oxygen gas)	Excellent
Sulfur dioxide (gas)	Unacceptable

Durability: built environments

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

Durability: flammability

Flammability	Non-flammable

Durability: thermal environments

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

Geo-economic data for principal component

Annual world production, principal component	1.18e8	-	1.19e8	tonne/yr
Reserves, principal component	3e9	-	3.1e9	tonne

Primary material production: energy, CO2 and water

Embodied energy, primary production	2.09	-	2.31	MJ/kg
CO2 footprint, primary production	0.186	-	0.206	kg/kg
Water usage	* 9.79	-	10.8	l/kg

Material processing: energy

Grinding energy (per unit wt removed)	* 2.72	-	3.01	MJ/kg

Material processing: CO2 footprint

Grinding CO2 (per unit wt removed)	* 0.204	-	0.225	kg/kg

Material recycling: energy, CO2 and recycle fraction

Recycle	✗	
Recycle fraction in current supply	0.1	%
Downcycle	✓	
Combust for energy recovery	✗	
Landfill	✓	
Biodegrade	✗	
Toxicity rating	Non-toxic	
A renewable resource?	✗	

Supporting information

Technical notes

In use plaster of Paris is mixed with half its weight of water. It remains usable for 20 minutes, starts to set after 30 and is solid after one hour.

Typical uses

External and internal molded decoration on walls and ceilings; as a mold material for casting low-melting metals; and as medical casts and splints.

Links

Reference

ProcessUniverse

Producers