Cement

Description

Image

Caption

1. Cement texture. © Titus Tscharntke - Public domain 2. Masonry trowel in bucket full of mortar. © Stanislaw Skowron at en.wikipedia - Public domain

The material

We use cement and concrete in vast quantities -- quantities second only to our consumption of water. Cement is a calcined, powdered ceramic that, with the addition of water, can be molded or poured and then sets into a solid mass, bonding well to many surfaces. There are many different cements; the one most widely used construction is Portland cement, so called because the developers sought to promote it as resembling Portland stone, a layered limestone much valued for floors and pavings (the resemblance is a poor one). It is made by calcining a mixture of chalk or limestone and clay, followed by grinding to a fine powder. Mixed with water, it hydrates and sets to a hard gray solid. Portland cement can be used neat, but is more usually used as a binder with aggregates to make mortar and concrete.

Composition (summary)

63% CaO, 21% SiO2, 6% Al2O3 + additions, hydrated

General properties

Density		112	-	137	lb/ft^3
Price	*	0.0454	-	0.0544	USD/lb
Date first used		-200			

Mechanical properties

Young's modulus	*	4.38	-	6.03	10^6 psi
Shear modulus	*	1.89	-	2.47	10^6 psi
Bulk modulus	*	2.76	-	3.6	10^6 psi
Poisson's ratio	*	0.2	-	0.24	
Yield strength (elastic limit)	*	0.276	-	0.435	ksi
Tensile strength	*	0.276	-	0.435	ksi
Compressive strength		3.48	-	3.92	ksi
Elongation		0			% strain
Hardness - Vickers	*	5.6	-	6.2	HV
Fatigue strength at 10^7 cycles	*	0.131	-	0.203	ksi
Fracture toughness		0.319	-	0.41	ksi.in^0.5
Mechanical loss coefficient (tan delta)		0.01	-	0.03	

Thermal properties

Melting point		1.71e3	-	2.19e3	°F
Maximum service temperature		1.16e3	-	1.57e3	°F
Minimum service temperature		-256	-	-238	°F

Thermal conductor or insulator?		Poor insulator		
Thermal conductivity		0.462	- 0.52	BTU.ft/h.ft^2.F
Specific heat capacity	*	0.194	- 0.207	BTU/lb.°F
Thermal expansion coefficient		6.67	- 7.22	µstrain/°F

Electrical properties

Electrical conductor or insulator?		Poor insulator		
Electrical resistivity		2e11	- 2e12	µohm.cm
Dielectric constant (relative permittivity)	*	8	- 12	
Dissipation factor (dielectric loss tangent)	*	0.001	- 0.01	
Dielectric strength (dielectric breakdown)		36.6	- 40.6	V/mil

Optical properties

Transparency	Opaque

Processability

Moldability	4	- 5	

Eco properties

Embodied energy, primary production		585	- 650	kcal/lb
CO2 footprint, primary production		0.906	- 1	lb/lb
Recycle	✗			

Supporting information

Design guidelines

When water is added to cement paste, a chemical reaction starts that causes the mass to stiffen ("setting") and to develop strength ("hardening"). Portland cement reaches a compressive strength of 13 - 18 MPa after 3 days, and 24 - 27 MPa after 28 days. High alumina cement hardens more quickly, reaching up to 48 MPa in 3 days. The faster hardening cuts construction costs, but its incorrect use has led to failures. Polymers can be added to cement to increase durability and reduce permeability.

Technical notes

Cements, clays and certain glasses are based on three main ingredients: silica (SiO2), alumina (Al2O3) and lime (CaO), sometimes with a fourth, iron oxide (Fe2O3). In cement-speak these are referred to as S, A, C and F. Thus the main constituents are reported as C3S, meaning 3(CaO).SiO2, C3A, meaning 3(CaO).Al2O3, and so on. The used of cement is covered by standard BS 12 (1958)

Typical uses

Vast quantities of cement are used to make concrete for general civil engineering construction, where there is little exposure to sulfates in soil or groundwater. Cements are also used as mortars to cement brick, and as rendering on walls and floors.

Links

Reference

ProcessUniverse

Producers