PUMICE LIGHTWEIGHT CONCRETE

A short introduction to design and properties

Pumice lightweight concrete

Definition

- Concrete containing pumice as lightweight aggregate.

Description

Generally lightweight aggregates and lightweight concrete shall have bulk density (unit weight) according to Table 1 .

Table 1. Bulk density of some lightweight materials

Material	Bulk density
lightweight aggregates	less than 1200 kg/m^3
lightweight concrete (dry)	800 - 2000 kg/m^3
lightweight aggregates	Particle density
	less than 2000 kg/m^3

- Colour: Usually light gray.

Applications for lightweight pumice units

- Controlled Low-Strength Material (CLSM) for backfilling
- Subbase for floor tiling
- Floor inclination for drainage
- Roof thermal insulation

Some references to European specifications and testing standards

- EN 206-1: Concrete - Part 1: Specification, performance, production and conformity
- EN 13055-1 Light-weight aggregates - Part 1: Light-weight aggregates for concrete and mortar
- EN 992:1995 Determination of the dry density of lightweight aggregate-concrete with open structure.
- prEN 1745 Masonry and masonry products - Methods for determining design thermal values.
- EN ISO 6946:1996 Building components and building elements – Thermal resistance and thermal transmittance – Calculation method.
- ISO 8302 Thermal insulation – Determination of steady-state thermal resistance and related properties – Guarded hot pate apparatus.

Raw materials

- Principal: Portland cement, pumice, water.
- Secondary: Plasticizers, water repellents, air-entrainment agents.

Production process

- Mixing of the constituents in ready mix unit or in small in situ concrete mixers. The use of air entraining admixture increases definitely the workability and decreases the bulk density of the final product.

Curing

- Due to the porosity of pumice, enough water is retained in the pores for the hydration of cement, minimizing the curing actions.

Properties and characteristics

- Compressive strength in the range 1 to 6 MPa at 28 days.
- Dry density of pumice concrete: 800-1600 kg/m^3 (against: dry density of ordinary aggregate concrete ~ 2350 kg/m^3).
- Thermal conductivity of pumice concrete ($\lambda_{10,dry}$): 0,20 – 0,38 W/m/K. Pumice concrete is a heat-insulating material. Thermal conductivity vs dry density is presented in Table 2.

Table 2 Thermal conductivity vs. dry density of pumice concrete

Dry density	Thermal conductivity
kg/m^3	W/m/K
800	0,20
900	0,23
1000	0,28
1200	0,38

Thermal conductivity increases by 4% when moisture content increases by 1% w/v.

- Pumice concrete is produced by inorganic materials and they do not release harmful gases in the case of fire.
- Pumice concrete is a material friendly to the environment.
- Increase of cement content results in an increase of the compressive strength and the density of pumice lightweight concrete.

Typical designs and properties

- Typical mix designs and properties of pumice lightweight concrete are presented in the Table 3.
- It is noticed that compressive strength and CBR values at 2 days are high enough to allow works (e.g. tiling, walking) on the surface of the pumice lightweight concrete.

Table 3. Indicative mix designs and properties for pumice lightweight concrete

Constituents and content				
Pumice with 19,5% moisture	kg/m^3	860	840	890
Water	kg/m^3	175	200	245
Cement CEM II 32,5	kg/m^3	145	175	215
Air entraining admixture	kg/m^3	0,8	1,0	1,2
Properties				
Air content	% v/v	28	23	18
Slump	cm	18	18	24
Bulk density of fresh concrete		1180	1220	1345
Bulk density of hardened concrete at 28 days		1140	1230	1290
Compressive strength at 2 days	MPa	0,31		0,74
Compressive strength at 3 days	MPa		0,98	
Compressive strength at 7 days	MPa	0,71	1,39	1,66
Compressive strength at 28 days	MPa	1,54	2,88	3,60
CBR (California bearing ratio) at 2 days	%	23,3		50,5
CBR (California bearing ratio) at 3 days	%		54,5	
CBR (California bearing ratio) at 7 days	%	38,5	75,7	101,5
CBR (California bearing ratio) at 28 days	%	110,2	130,0	165,6
Drying shrinkage at 28 days	%	1,7	1,7	1,7

References

- A. Short and W. Kinniburgh: ***Lightweight concrete***, 1962, J. Wiley & Sons.
- A.M. Neville ***: Properties of Concrete***, 1995, Longman.
- CIBSE Guide, A3, 1989, The Chartered Institution of Building Services Engineers, London : ***Thermal Properties of Building Structures***