

Pumice Stone

Applications in Building Sector

LAVA
MINING AND QUARRYING Co

HERACLES GROUP OF COMPANIES

A member of LafargeHolcim

Pumice stone in building sector

Benefits from a natural, lightweight product with zero CO2 emissions

Topics to be addressed

- Pumice technical properties
- Pumice blocks
- Structural pumice concrete
- Low strength pumice concrete (MASTER FLOOR)
- Pumice Shotcrete (Gunitech)
- Precast pumice walls
- Pumice as pozzolan



Pumice

Technical properties

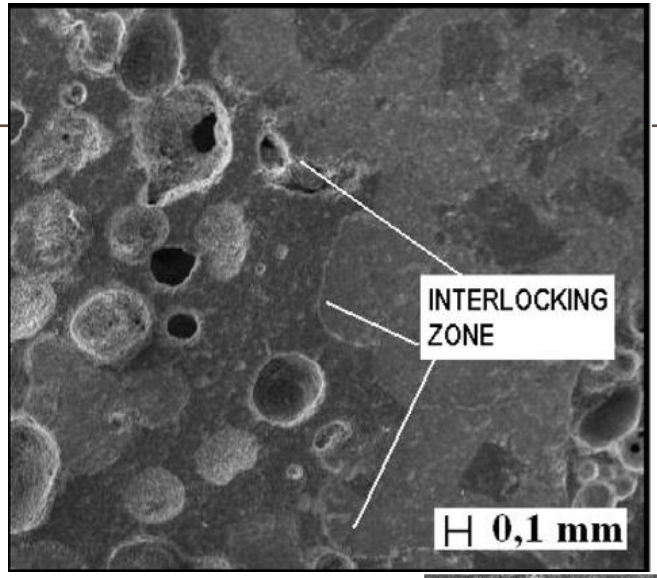
- Natural, inert, lightweight, porous material expanded during volcanic eruption
- Environmental friendly
  - ❖ No energy consumption for expansion
  - ❖ No CO2 emissions
- Low Loose Bulk Density (600-800 kg/m3 in a dry basis)



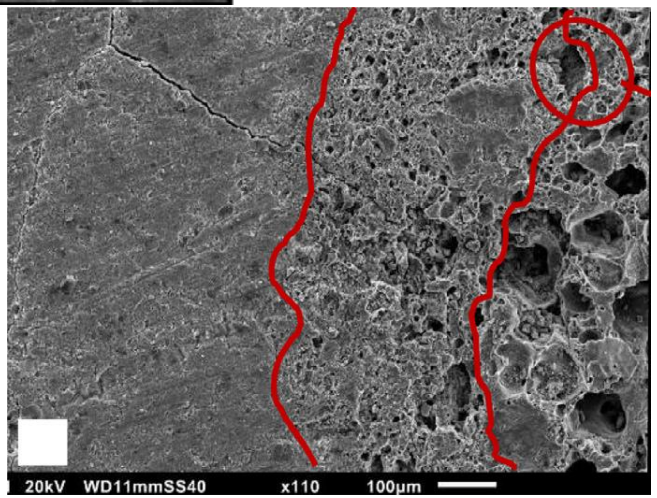
Silicon Dioxide SiO_2	71.91%
Aluminium Oxide Al_2O_3	12.66%
Ferric Oxide Fe_2O_3	1.13%
Calcium Oxide CaO	1.46%
Magnesium Oxide MgO	0.32%
Sulphur Trioxide SO_3	0.03%
Potassium Oxide K_2O	4.30%
Sodium Oxide Na_2O	3.45%
Loss on Ignition	4.53%

Pumice

Technical properties



- Safety
  - ❖ Non combustible
  - ❖ Fire resistant
- Porous structure
  - ❖ Thermal insulation
  - ❖ Sound insulation
  - ❖ Internal concrete curing
  - ❖ Surface interlocking
- Pozzolanic material
  - ❖ Chemical bonding with cement paste
- Highest crushing resistance (EN 1055-1 A) 4,9 MPa among all natural lightweight aggregates
  - ❖ Improve lightweight concrete strength



- Inert for reinforcing bars (Cl and SO4 similar or much lower than artificial expanded lightweight aggregates)

Pumice blocks

Key characteristics

- **Material density:** 900 – 1300 kg/m3
- **Block density**: 450-650 kg/m^3
- **Strength at 28 days:** >3MPa
- **Material thermal conductivity, λ**: 0,22 - 0,38 W/(m K)
- **High sound absorption behavior**
- **Excellent fire resistance**
- **Good seismic behavior**
- **Ecological product**
- **Drying shrinkage: 0,03 – 0,06 %**
- **Water absorption: 17-20 % m/m**









Pumice blocks

Mix design

Typical **Mix Formulation** per Batch for Blocks with only Pumice Aggregates:

Cement Type I or II: 140-200kg
Pumice 0-8mm (in a wet basis): 700-750 kg
Pumice 2-10mm (in a wet basis): 200 -250 kg
Additional Water: 60-100 L
Pumice concrete dry density: 1000 - 1200 kg/m^3



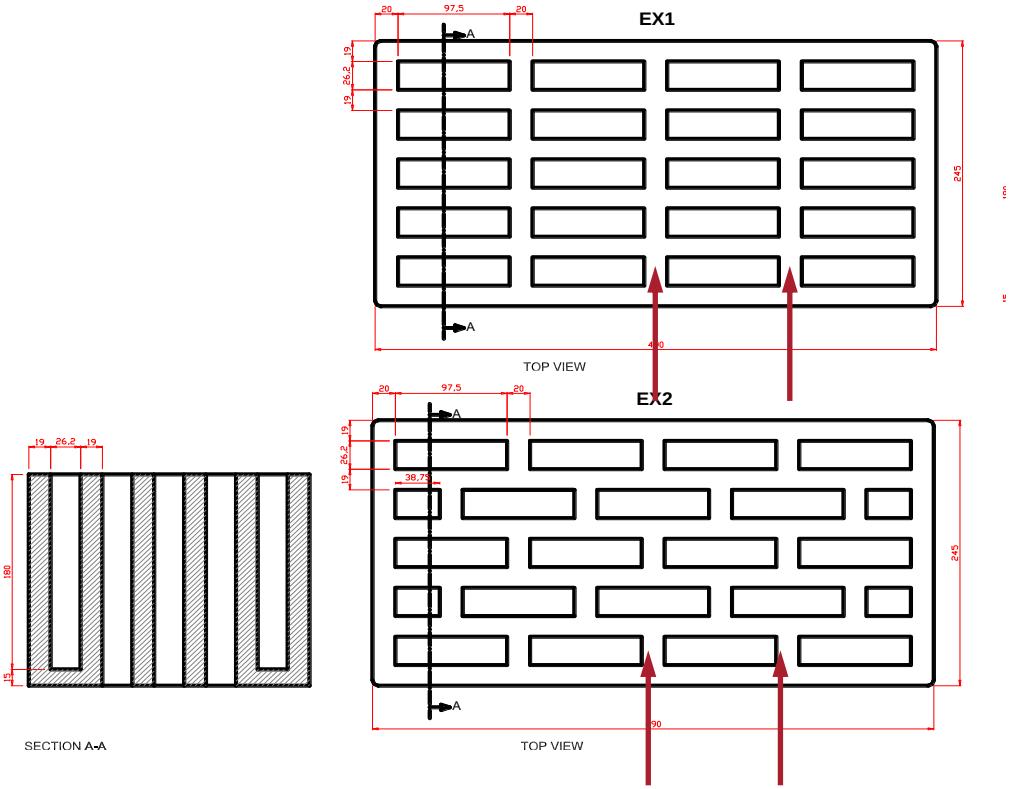
Important Note:

- Cement affects mainly the strength of the blocks
- The moisture of pumice is at the range 16-26% (in a wet basis). If pumice is dry, it is strongly recommended the pre-wetting of pumice
- Adjustment of water is crucial for the formation and strength of the “wet” block

Pumice blocks

Aspects on design

High lateral strength
(compressive load)



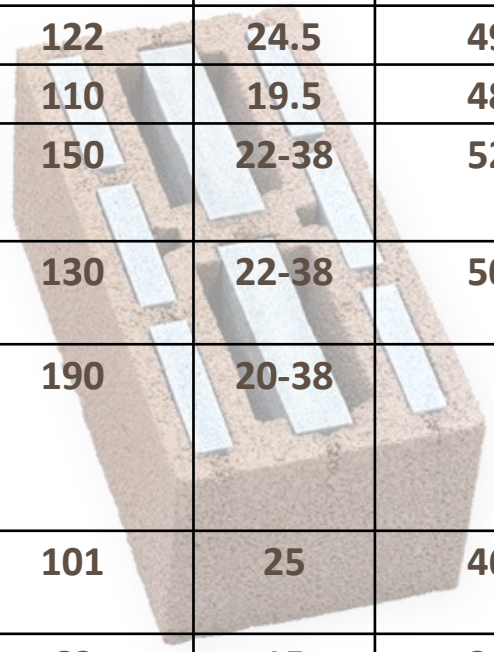
Low lateral strength
(bending load)

		EX1	EX2
MASONRY UNIT - PUMICE BLOCK			
m	Width	**0,245**	**0,245**
m	Length	**0,490**	**0,490**
m	Total height	**0,195**	**0,195**
m	Base thickness	**0,015**	**0,015**
kg/m^3	Pumice concrete density	**1000**	**1000**
W/(m·K)	Thermal conductivity	**0,290**	**0,290**
kg/m^3	Expanded polystyrene density		
W/(m·K)	Thermal conductivity		
MASONRY MORTAR			
m	Horizontal joint thickness	**0,005**	**0,005**
m	Vertical joint thicness	**0,000**	**0,000**
kg/m^3	Masonry mortar density	**1800**	**1800**
W/(m·K)	Thermal conductivity	**0,800**	**0,800**
RENDER			
m	Thickness	**0,020**	**0,020**
kg/m^3	Density	**500**	**500**
W/(m·K)	Thermal conductivity	**0,140**	**0,140**
PLASTER			
m	Thickness	**0,020**	**0,020**
kg/m^3	Density	**500**	**500**
W/(m·K)	Thermal conductivity	**0,140**	**0,140**
SURFACE RESISTANCE			
m^{2}K/W	External	**0,040**	**0,040**
m^{2}K/W	Internal	**0,130**	**0,130**
RESULTS			
m^{2}K/W	Masonry unit thermal resistance	**1,203**	**1,207**
W/(m K)	Equivalent thermal conductivity	**0,204**	**0,203**
W/(m^{2}K)	**Wall thermal transmittance**	**0,634**	**0,633**
m	Wall width	**0,285**	**0,285**
kg	Masonry unit mass	**13,8**	**14,0**
kg/m^3	Masonry unit bulk density	**588**	**596**
%	Total voids	**41,2**	**40,4**
unit/m^2	Units/m^2 wall	**10,2**	**10,2**
kg/m^2	Wall mass/m^2	**169**	**171**

Pumice blocks

Insulation comparison

Wall Type	Wall weight, kg/m²	Width, cm	Sound Red., R_w, dB	Thermal Transm., U, W/(m²K)
LAVAWALL® A25 Super Plus	122	24.5	49	0,39- 0,41
LAVAWALL® A25 Plus	122	24.5	49	0,52- 0,54
LAVAWALL® A20 Plus	110	19.5	48	0,60-0,61
LAVAWALL® A10 Std Double + NEOPOR TX EPS 100 (30mm - 40 mm)	150	22-38	52	0,49 – 0,42
LAVAWALL® A10 Std + A10 Plus + NEOPOR TX EPS 100 (30 mm - 40 mm)	130	22-38	50	0,42 – 0,37
CLAY BRICK 19X9X12 Double + XPS 30 mm 50 mm 70 mm	190	20-38		0,74 0,52 0,40
Autoclaved Aerated Concrete block 60x25x25	101	25	46	0,40
Autoclaved Aerated Concrete block 60x25x15	62	15	38	0,63



EPS: Expanded polystyrene
XPS: Extruded polystyrene

Pumice blocks

Fire resistance (test EN 1363-1)



- Wall of 9 cm pumice blocks
- Duration: 3 h from 300 °C to 1110 °C
- External temperature: decade degrees lower than required in the standard
- Total integrity of the wall



University of Patras
Dept. of Civil Engineering

Structural pumice concrete

With the experience of a highly seismic European country



- Introduction of the structural pumice-concrete in the Greek normative frame (in a seismic environment)
- Documentation in Greek conditions

Structural pumice concrete

An R&D project supported by state funding

- **Structural lightweight concrete**
  - Greek regulations: No provision for use
  - **Earthquake risks**
  - EN 206: … **LC20/22, LC 25/28, LC 30/33,**… LC 80/88
  - EUROCODEs
  - ACI 211.2-98 και ACI 213R-03
- **Pumice concrete**
  - Reduced dry density (~1500 kg/m3)
  - Reduced thermal conductivity (λ~0,6 W/m/K)
- **LH / Heracles GCC,** EKET, LH A&C, LAVA
  - National Technical University of Athens NTUA



Certified total expense: 296 k€

State funding: 145 k€

Structural pumice concrete

RMX trials

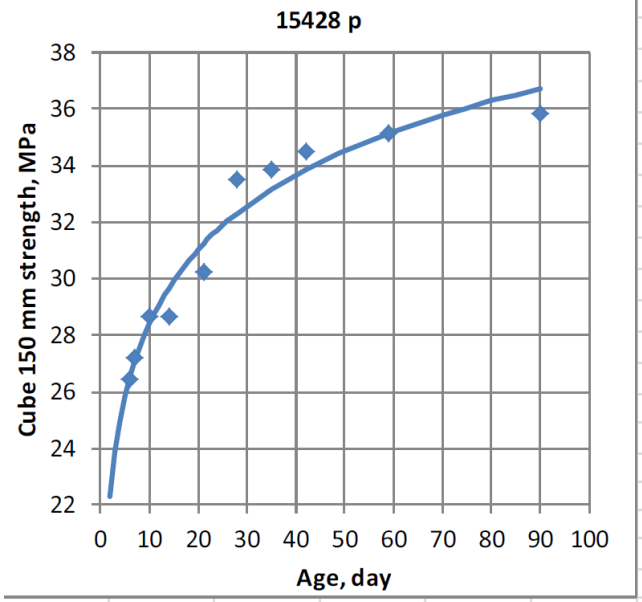
- **Lafarge Beton Rafina RMX trials**
  - ❖ CEM II /B-M (P-W-L) 42,5 N
  - ❖ Pumice size 0-8 mm
  - ❖ Plain pumice concrete
  - ❖ Metallic fiber pumice concrete L= 60 mm
  - ❖ Pumice/sand lightweight concrete
- **Non saturated pumice**



- **Objectives**
  - ❖ Real conditions production - Troubleshooting
  - ❖ Production and delivery to NTUA for large scale specimens
  - ❖ Production of numerous specimens for lab tests

Structural pumice concrete

An example



Flex. 10x10x50 C78 meas.	
age, d	MPa
7	3,3
28	4,8
59	5,2

Strength 15x15x15 meas.	
age, d	MPa
7	27,2
28	33,5
59	35,1

Brazilian 10x30 meas.	
age, d	MPa
28	2,1
59	3,1

Mod. elasticity 10x20 meas.	
age, d	MPa
90	21,1

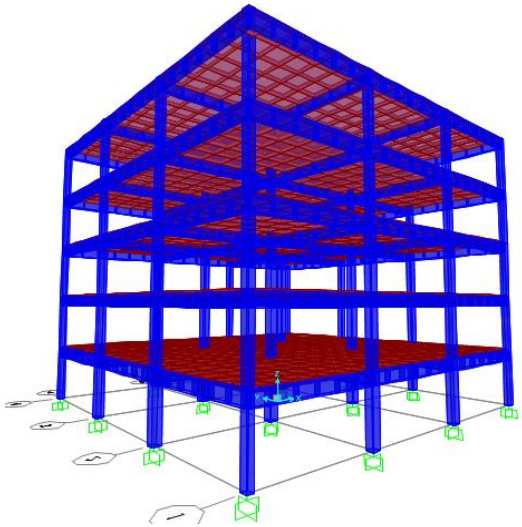
		15428 p
cement II42,5	kg/m^3	406
pumice 0-8 dry	kg/m^3	854
sand	kg/m^3	
fibers	kg/m^3	
pumice moist.	kg/m^3	271
add water	kg/m^3	120
Superplasticizer	kg/m^3	4,9
Retarder-plasticizer	kg/m^3	2,5
wadd/c	kg/m^3	0,30
wtot/c	kg/m^3	0,96
weff/c	kg/m^3	0,29
water abs. dry-b	%	31,9
total water	kg/m^3	391
pumice moist. wet-b	%	24,1
sand mois. wet-b	%	1,0
app. dens. wet	kg/m^3	1659
air meas. v/v	%	5,1
air calc. v/v	%	10,0
slump 10 min	cm	15
slump 30 min	cm	15
slump 60 min	cm	16
app. dens. 28d wet	kg/m^3	1633
app. dens. 28d oven dry	kg/m^3	1477
app. dens. 59d wet	kg/m^3	1654
app. dens. 59d oven dry	kg/m^3	1469

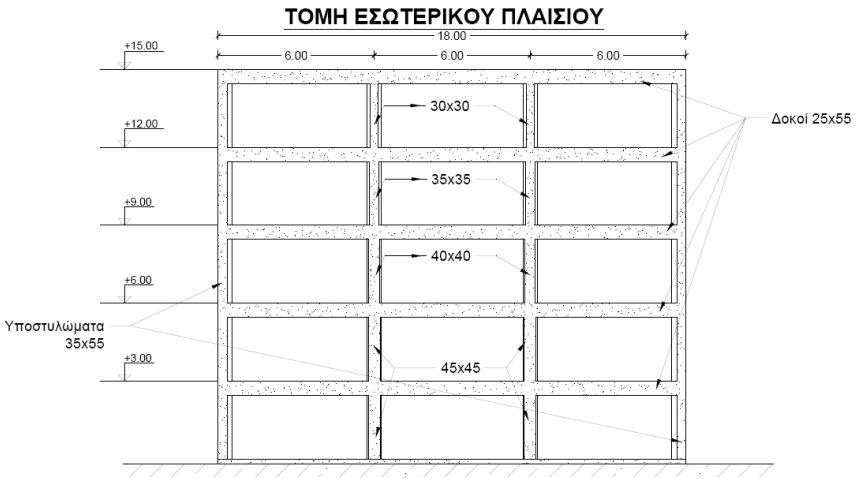




Structural pumice concrete

Material Cost – Comparison with normal weight concrete

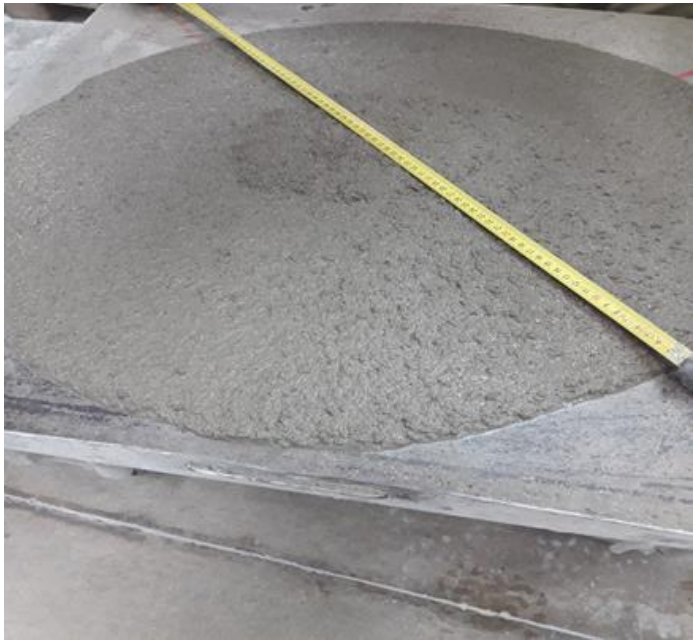




		NC	PC	NC	PC
Columns		**37**	**45**	**13418**	**6377**
Beams		**108**	**99**	**12099**	**6471**
Slabs		**260**	**231**	**12897**	**11713**
Total		**406**	**375**	**38415**	**24561**
Reduction		**7%**		**36%**	
Selling price	€/m3, €/t	**50**	**83**	**620**	**620**
Total	€	**20300**	**31125**	**23817**	**15228**
Grand total	**€**			**44117**	**46353**

Structural pumice concrete

Self compacting structural pumice concrete



Self compacting pumice concrete		
CEM I42,5R	kg/m^3	390,9
Pumice 0/8 mm	kg/m^3	579,0
Sand 0/4 mm	kg/m^3	595,2
Water of moisture	kg/m^3	66,0
Water added	kg/m^3	223,4
Plastiment 40	kg/m^3	2,0
Viscocrete Ultra 450	kg/m^3	7,8
Air	L/m^3	85
Density wet	kg/m^3	1884
Spread	cm	66
CS 5days	MPa	34,2
CS 7days	MPa	36,0

Structural pumice concrete

An overview

- **Low density:** 1350 – 1800 kg/m^3 oven dry
- **High mechanical strength at 28 days**: even more than 40 MPa
- **Reduced loads in building** (gravitational)
- **Reduced seismic loads** (inertial)
- **Fulfills EUROCODE 2 and 8**
- **Pumpable**
- **Thermal conductivity λ**: ~ 0,6 W/(m K)
- **Very low chloride ion penetration:** 300-600 Cb (ASTM C 1202)
- **LH France** has launched in the market a structural LC with **LAVA Pumice Stone** under the brand name **Thermedia** (lower photo) with **thermal conductivity** in the range **0,3 – 0,6 W/(m K)**





Structural pumice floor projects after finishing and epoxy covering

Construction with Thermedia

Customer Discovery

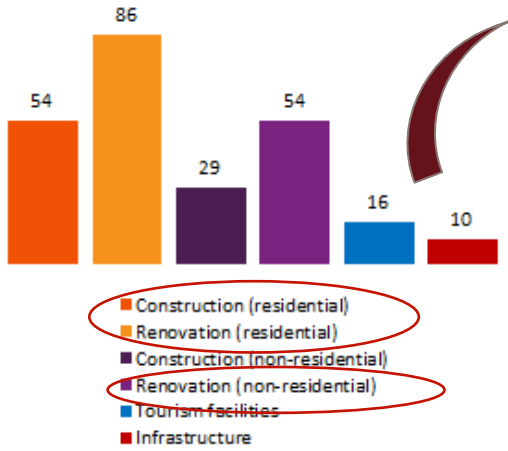
Research highlighting market trends, related construction types & materials

"Renovation" is the construction type that dominates the market.

The most common **applications** in Renovation projects are related to **wall & floor repair.**

Floor filling, wall repairing & construction products are in high demand.

Most common constructions types
(Top 3)



Renovation residential

86%

Repairing of masonry walls	91%
Repairing of floors	67%
Construction of masonry walls	67%
Landscaping	65%
Waterproofing & insulation of terraces	57%

Renovation non-residential

54%

Repairing of masonry walls	85%
Repairing of floors	68%
Waterproofing & insulation of terraces	56%
Landscaping	56%
Construction of masonry walls	53%

	Construction of masonry walls		Brick Laying		Repairing of masonry walls	
	End-users (62%)	*Retailers (55%)*	*End-users (53%)*	*Retailers (57%)*	*End-users (83%)*	*Retailers (69%)*
Bulk cement	0	0	0	0	0	0
Bagged cement	76	76	84	85	72	63
Concrete	0	0	0	0	0	0
Special concrete	0	0	0	0	0	0
Aggregates	54	54	0	0	50	47
Lightweight aggregates	0	0	0	0	0	0
Steel	0	0	0	0	0	0
Prefab elements	0	0	0	0	0	0
Bricks & Rooftiles	78	73	81	77	0	0
ALFA BLOK/ YTONG	43	47	59	45	0	0
Precast	0	0	0	0	0	0
Plaster boards	51	28	0	0	0	0
Ready mix mortars (plasters)	62	64	0	0	88	87

HERACLES GROUP OF COMPANIES

New Offers range application matrix

Pumice based products offering competitive advantage & addressing client needs

Company is planning a number of **product launches,** to **offer value adding solutions** in most common construction types

Co-operation with Group, **Lab and Field testing** plus **market research** to validate offers are: meaningful, relevant and profitable

Production, Technical Support and Commercial depts. participate in development

Construction Types	Applications	MASTER BLOCK	PUMICE WALLS	MASONRY CEMENT	FLOOR FILLING PUMICE MIX	PUMICE GUNITE	GROUND LIMESTONE
Residential & Non - Residential Construction	Construction of masonry walls	X	X	X			X
	Waterproofing & insulating terraces			X	X		
Residential & Non - Residential Renovation	Repairing of masonry walls			X		X	
	Repairing of floors			X	X		
	Construction of masonry walls	X	X	X			X
	Waterproofing & insulating terraces			X	X		

MASTER FLOOR

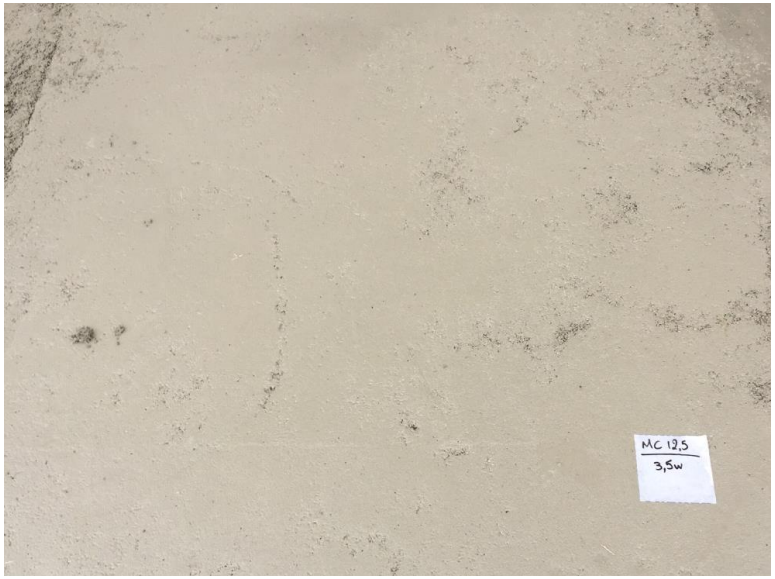
Low strength pumice concrete (floor filling applications)



MASTER FLOOR

Constituents and uses

- **Main constituents in big-bag**
  - Pumice 0/3 mm
  - Sand 0/4
  - PP fibers
  - Admixtures
- **Cement is mixed separately**
- **Usages**
  - Floor substrate for tiling
  - Draining inclination
  - Roof thermal insulation





MASTER FLOOR

Indicative mix design

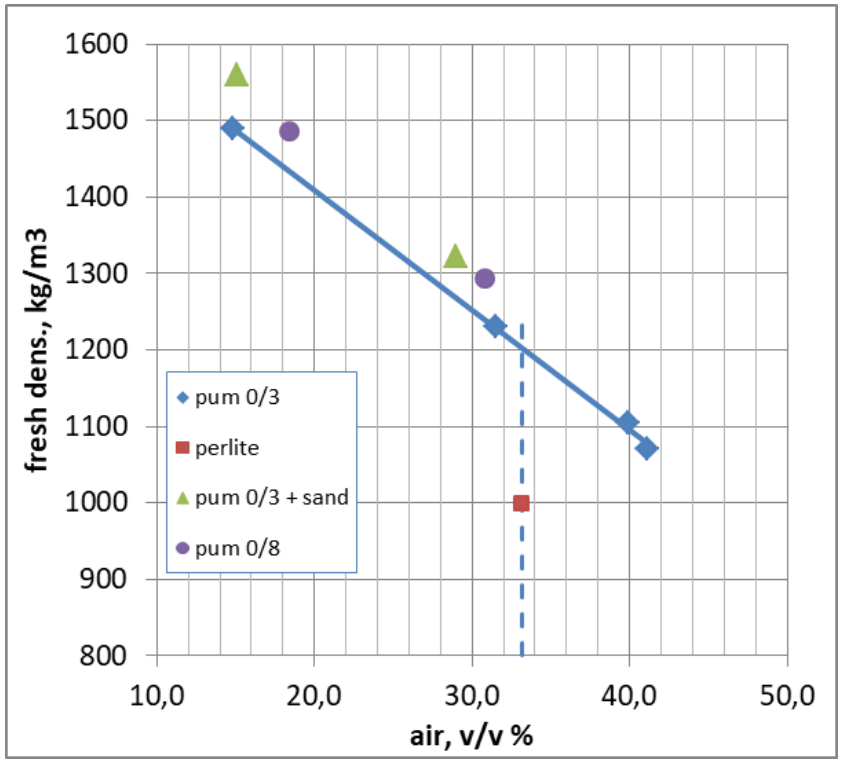
CEM II 32,5	kg/m^3	236	203
Air entrainment agent	kg/m^3	0	0,41
MASTER FLOOR	kg/m^3	1.013	874
Water moisture	kg/m^3	108	93
Water added	kg/m^3	317	212
Air	L/m^3	74	262
Slump	cm	14,5	16,5
Wet density	kg/m^3	1.670	1.380
CS, 1 d	MPa	1,3	0,6
CS, 4 d	MPa	3,1	1,8
CS, 7 d	MPa	3,8	2,4
CS, 28 d	MPa	6,9	5,1

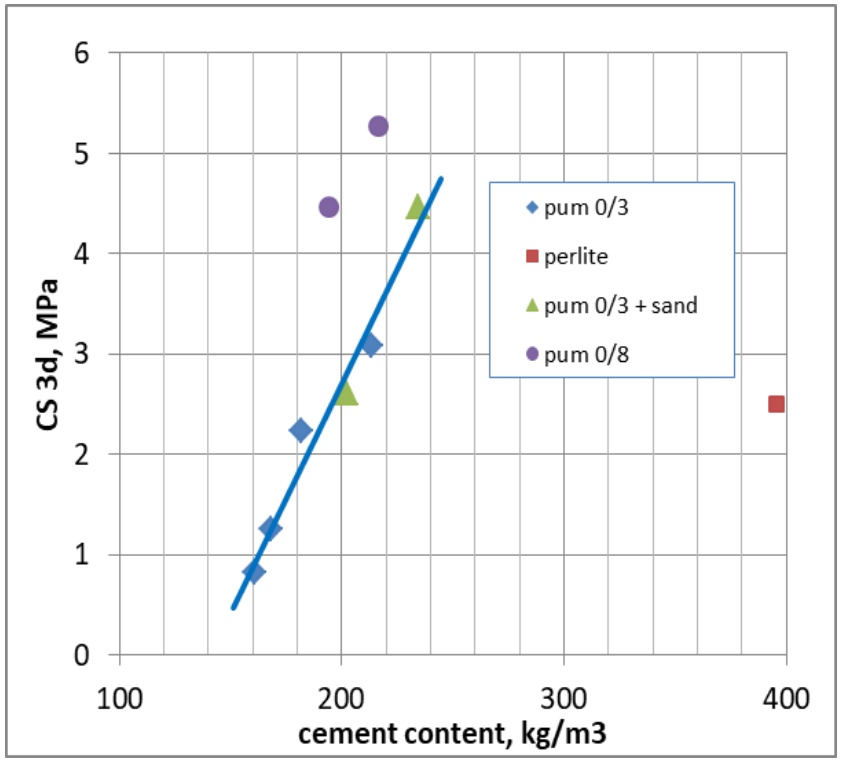




MASTER FLOOR

Practical correlations





GUNITECH

Pumice based dry shotcrete





GUNITECH
A joined development

- A collaboration between HERACLES and Sika Hellas

- **Applications**
  - ❖ Reinforcement of thin walls
  - ❖ Transforming of filling walls to load bearing ones
  - ❖ Wall panels construction
  - ❖ Structural mantles
  - ❖ Manual repairs



GUNITECH

Indicative mix design

		T2	T3 ref
CEM I 52,5N	kg/m^3	450	450
Crushed sand 0-4 mm	kg/m^3		1.717
Sand 0-4 mm		330	
Pumice LAVA 0-3 mm moist. 24,8 %	kg/m^3	797	
Water	kg/m^3	131	198
Accelerator (Sigunit - 49AF)	% cem	5,0	5,0
Silica fume	% cem	10,0	0,0
SikaFiber Force PP-540/52	kg/m^3	2,0	2,0
Rebound	%	22	38
Density	kg/m^3	1.836	2.200
Density reduction	%	17	0 (ref)



GUNITECH

Lab testing



			T2	T3 ref	EN 1504-3 R3
			46563	46564	requirement
Bond strength (EN 1542:1999)		MPa	1,35	2,01	
Compressive strength (EN 12504-1 or EN 14888-1)	1d	MPa	18,7	16,5	
	7d	MPa	29,1	27,6	
	28d	MPa	30,1	28,6	≥25
Carbonation Resistance (EN 13295)			Pass up to 56 d		
Capillary absorption (EN 13057)		kg m^{-2} $h^{-0,5}$	0,375	0,28	≤0,5
Elastic Modulus (EN 13412, ASTM C 469)		GPa	14,1 (28 d)	19,3 (28 d)	≥15
		GPa	19,3 (33 d)		

GUNITECH

The product

Product

- Two components product, in bags
  - ❖ Comp. A': HERACLES cement + limestone + fibers & chemicals
  - ❖ Comp. B': LAVA pumice

- **Applications / Features**
  - ❖ Application on concrete structures, repair applications etc
  - ❖ Low rebound 20% vs. 40 % of usual dry mortars
  - ❖ High compressive strength (30 MPa at 7d)
  - ❖ Lighter construction / use of pumice stone



Status:

Final large scale field trials / EN 1504 certified (repairing mortars)

GUNITECH

Value proposition

- **Lightweight** (25% less weight on the structure vs normal)
- **Ready** to use
- **Certified** quality of the final mix
- **Durability** enhancement (certified)
- Excellent **dry application** (due to pumice)
- Very good **bonding strength**
- Reduction of **rebound** (more than 20% vs normal)
- Reduction of **dust** emission
- Increased **energy absorption** in large deformation (plastic fibers)
- Very good **homogenization** and dispersion during shotcreting (pumpability)

EN 1504-3 R3



3_vid

Pozzolanic material in cement production





- Pumice is considered a **pozzolanic material (symbol P)** according to **EN 197-1:2011**
- **Appropriate raw material** for the production of **type II, IV, V** and **Sulfate Resistance (type IV) Cements**.
- **Reactive silica content ($rSiO_2$)** of pumice is at the range **48-56%. Exceeds the limitation of 25%** that EN 197-1:2001 sets.
- Pumice tested according to **ASTM C 595** and **fulfills the limit** of minimum **strength index 75% at 28 and 90 days** (ASTM C595 Table 3).

Method	Property		Range	Mean	Specifications
EN 196-2	Reactive SiO_2	%	48-56	53	min 25
ASTM C 595	Strength index at 7 days	%	73-82	77	---
	Strength index at 28 days	%	79-89	83	min 75
	Strength index at 90 days	%	87-100	92	---
in house	Workability index		84-100	94	---

Sales Technical Support

Ready to support any LH countries & International Clients

SALES TECHNICAL SUPPORT

Sales Technical Support department is staffed with highly sophisticated personnel with a **specialized experience** in pumice stone based products.

Accredited lab (EN ISO 17025) equipped for durability performance measurement .

Extensive experience also in:

- Advanced Concrete Technology & tailor made solutions
- Specialized lab tests for pumice based products
- Research Programs – collaboration with universities





For any further queries adding value to your local offers, please contact:

Christos Galmpenis

christos.galmpenis@lafargeholcim.com

www.lava.gr



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