International Conference Industrial Waste & Wastewater Treatment & Valorization *21 – 23 May 2015, President Hotel, Athens*

Incorporation of glass particles in high-performance mortars

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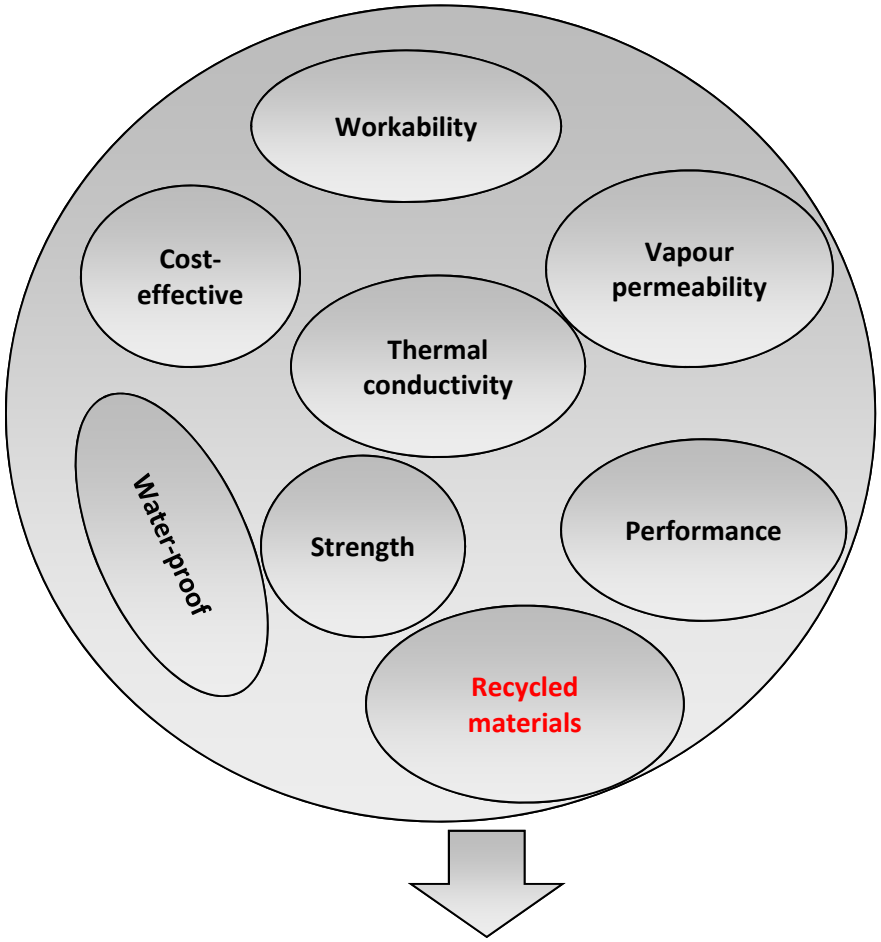
- Mortars are diachronic building materials used for bonding pieces of solid pieces of stone or brick, for protective or decorative covering or for making floors or substrates
- The mortar mixture consists of a binder, aggregates (sand) and water. The use of inorganic or organic additives is also known as an effort to improve mortar’s performance

Introduction

- Through centuries the demands in construction were increased as functional, aesthetic, economic and insulating criteria had to been fulfilled.
- In modern constructions another parameter that is taken into account is the reduction of energy consumption
- The development of chemical industry the last two centuries led to the production of a wide range of specialized materials that promise to give new properties such as better plasticity, anti-shrinkage properties, workability, anti-bacterial properties..
- **Demand: Mortars had to play a malty-phase role.**


DO NOT STEP ON THE
ANCIENT REMAINS


Workability
Cost-effective
Vapour permeability
Thermal conductivity
Water-proof
Strength
Performance
Recycled materials
High-performance mortars

Problematic

- The need for energy preservation is highly evident in the construction sector, which accounts for 40% of the energy consumption in the European Union
- Natural sand originating from rivers is becoming rare, the extraction of aggregates from quarries carries an increased administrative cost due to new legislation.
- The criteria and legislation for sand extraction are becoming more strict and demanding
- In some places good quality natural sands are not available.

- The annual demand in natural sands for repair works in 2013 from Greece was recorded a bit more than 1000tn

- The increased waste production offers the availability of large volumes of recycled materials

Properties related to aggregates

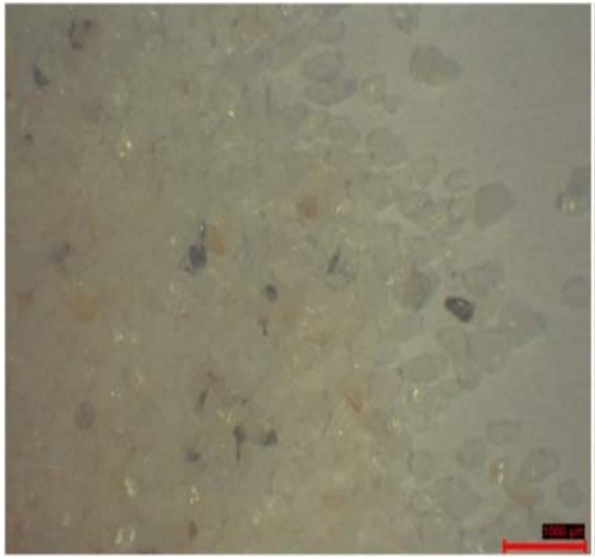
- rheology
- strength
- shrinkage
- porosity

are strongly based on the type, the ratio, and the gradation of the aggregates

Experimental part

- Cement-based mortars (white cement) were produced using 3 different types of aggregates of the same gradation (0-0.5mm)
- Mechanical, physical and structural properties were measured after 28days in order to record their performance

Experimental part-Aggregates



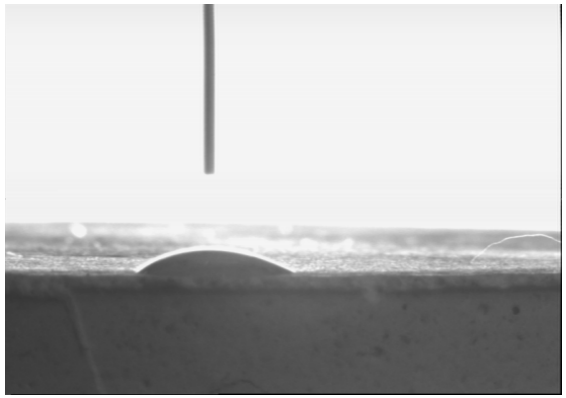
Natural sand

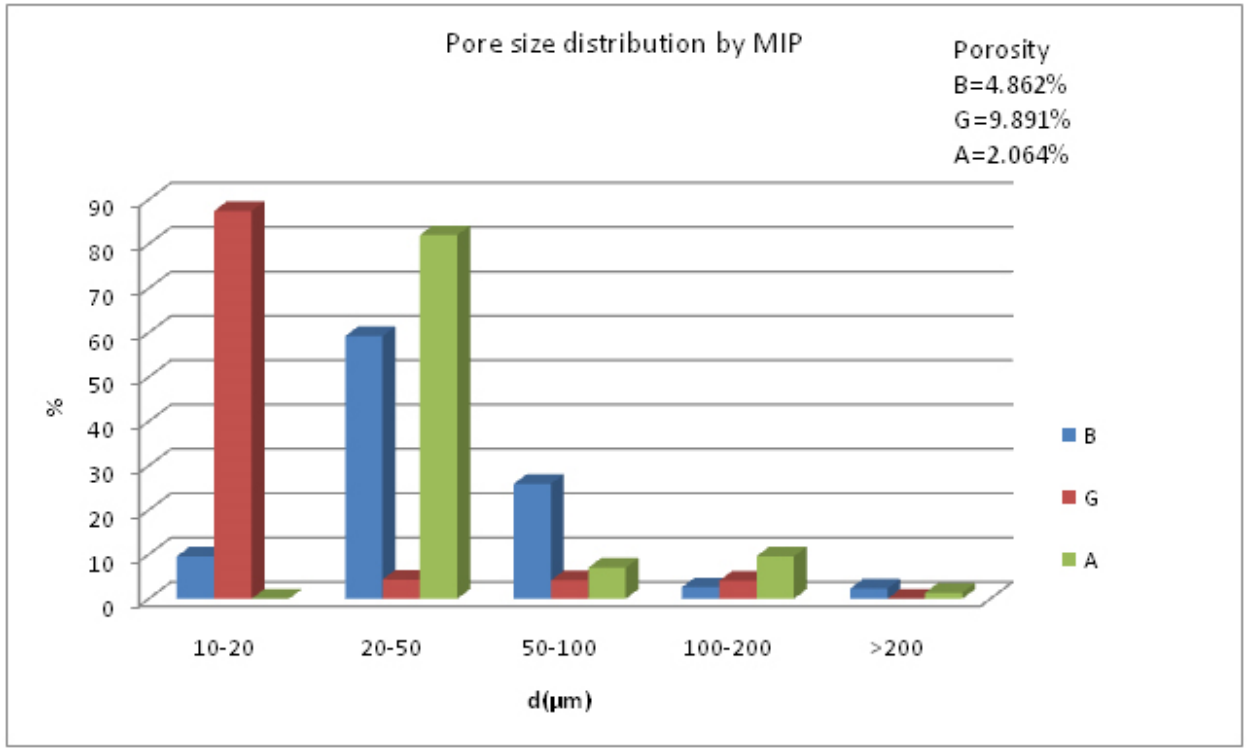
Glass spheres

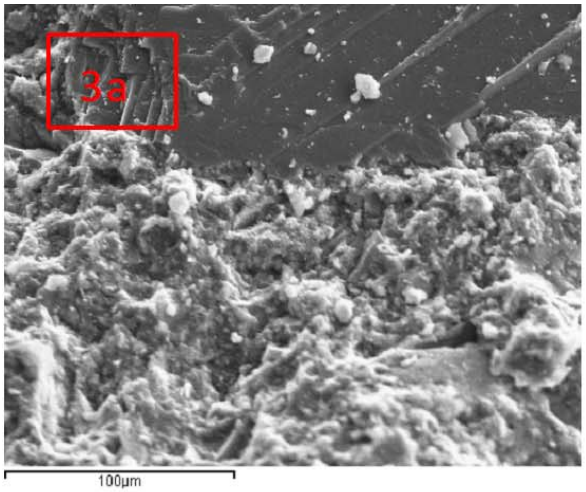
Recycled glass

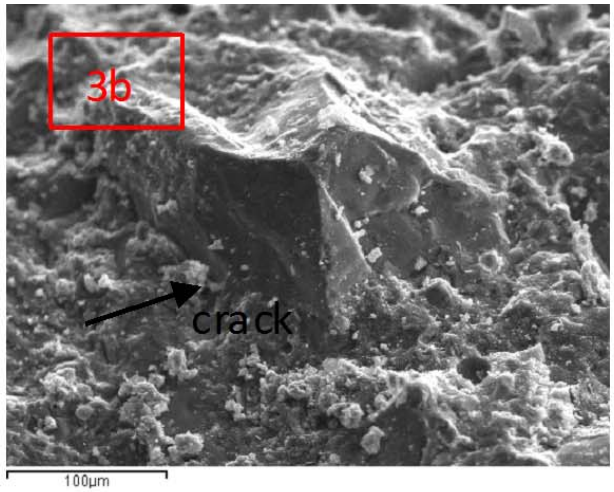
	White cement	Lime	Silica sand	Broken glass	Glass spheres	N/K	Workability (cm)
A1	1		1.5			0.55	15.2
A2	0.75	0.25	1.5			0.57	15.3
B1	1			1.5		0.62	15.9
B2	0.75	0.25		1.5		0.70	16.0
G1	1				1.5	0.92	14.1
G2	0.75	0.25			1.5	0.94	14.6

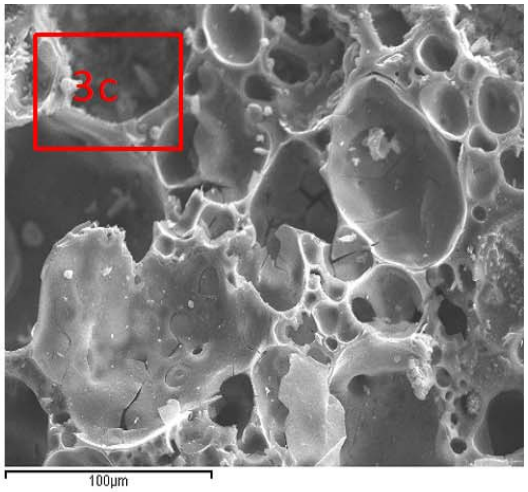
	Comp. strength MPa	Flex. Strength MPa	Porosity %	Capillary coefficient $g/cm^2min^{0.5}$	λ (W/m K)	Contact angle (°)	R(a) mm
A1	25.90	5.71	27.93	0.0124	1.33	85.7	
A2	19.05	4.56	27.23	0.0050	1.21	72	0.082206
B1	22.38	5.16	29.25	0.0196	1.03	38.2	
B2	12.88	4.69	30.85	0.0221	0.70	36.5	0.124787
G1	10.49	3.01	30.39	0.0072	0.57	33.7	
G2	6.77	2.15	31.93	0.0087	0.42	33.2	0.158151




Pore size distribution by MIP
Porosity
B=4.862%
G=9.891%
A=2.064%
90
80
70
60
50
40
30
20
10
0
%
10-20
20-50
50-100
100-200
>200
d(μm)
B
G
A


3a
100µm


3b
crack
100µm


3c
100µm

Conclusions

- An increased demand in water was recorded in order to achieve the required workability. A more stiff mixture is achieved in mortars containing glass particles in comparison with those containing silica sand.
- The glass particles of the different origin also introduced different properties in the mortar mixtures. A very porous structure was observed in the mortars containing the glass spheres due to the formation of rounded in shape pores of various diameter
- The interconnectivity of the pores is not high and thus the capillary coefficient in low. The induced porosity is probably responsible for the low values of the thermal conductivity (λ) imparting thermal insulating properties
- The microstructure is responsible for the high roughness recorded though the water drop analysis, which shows a hydrophilic material.

Conclusions

- The glass particles produced in the laboratory, by crashing bottles, were angular in shape.
- The formation of cracks in the transition zone between the grains and the binder was observed.
- The porosity recorded in these mortars present interconnectivity and the capillary coefficient was high.

Conclusions

- Improvement in the performance of mortars with incorporation of fine glass aggregates, in relation to capillary absorption and thermal conductivity relative to a conventional mortar, provides advantages in terms of behaviour /performance and recycling/environment.
- The use of fine recycled glass used as aggregates in masonry mortar manufacturing could be a viable alternative that would support sustainable development in the building sector.

THANK YOU FOR YOUR ATTENTION