

UNIVERSITA' DEGLI STUDI DI PAVIA

Department of Science of Earth and Environment



STUDIES FOR THE USE OF GEOPOLYMER MATERIALS TO REPAIR HISTORICAL STRUCTURES



Geopolymer Camp
Saint Quentin, France
6/8 July 2015

Marina Clausi

Marina.clausi01@universitadipavia.it

Outline



I. Studies of synthesis parameters

II. Studies for the use of geopolymers to repair historical structures



I. Studies of synthesis parameters



Materials

- Kaolin
 - Sibelco Italia, labelled SL-K

- Composition:

Component	Wt%	Component	Wt%
SiO ₂	67,00%	CaO	0.12%
Al ₂ O ₃	31,50%	MgO	0.23%
Fe ₂ O ₃	0.32%	K ₂ O	0.35%
TiO ₂	0.24%	Na ₂ O	0.00%
TOT.		99.76%	

- Sodium Silicate Solution (Ingessil S.r.l. Italy)



I. Studies of synthesis parameters



Synthesis parameters

$\text{SiO}_2/\text{Al}_2\text{O}_3$	$\text{Al}_2\text{O}_3/\text{Na}_2\text{O}$	$\text{H}_2\text{O}/\text{Na}_2\text{O}$	Water/solid
3.7	1.04	10	0.33
3.7	1.04	12	0.40
3.7	1.04	14	0.46
3.7	1.04	16	0.53
3.7	1.04	20	0.66

T = 20 °C

UR = 65%

Time = 28 day

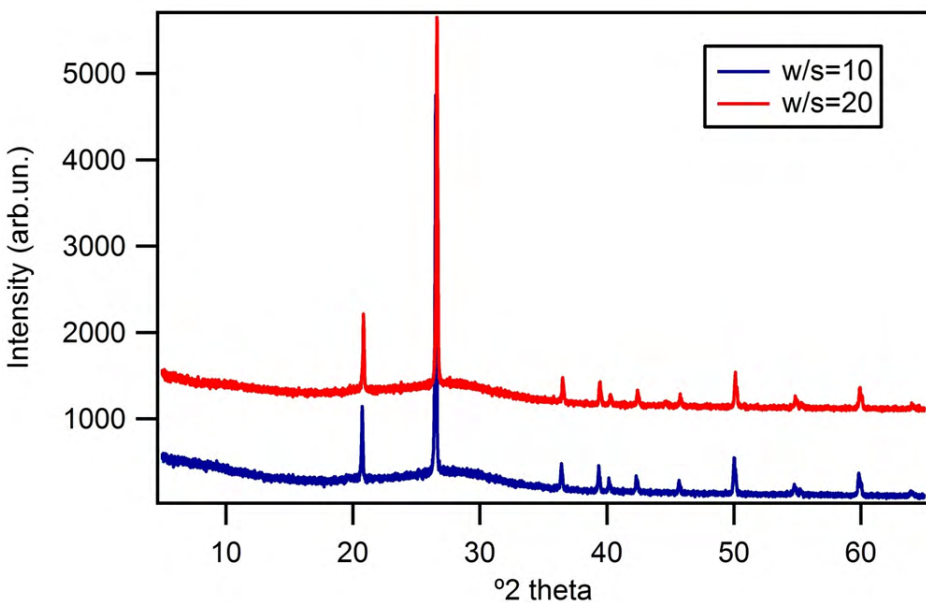


I. Studies of synthesis parameters

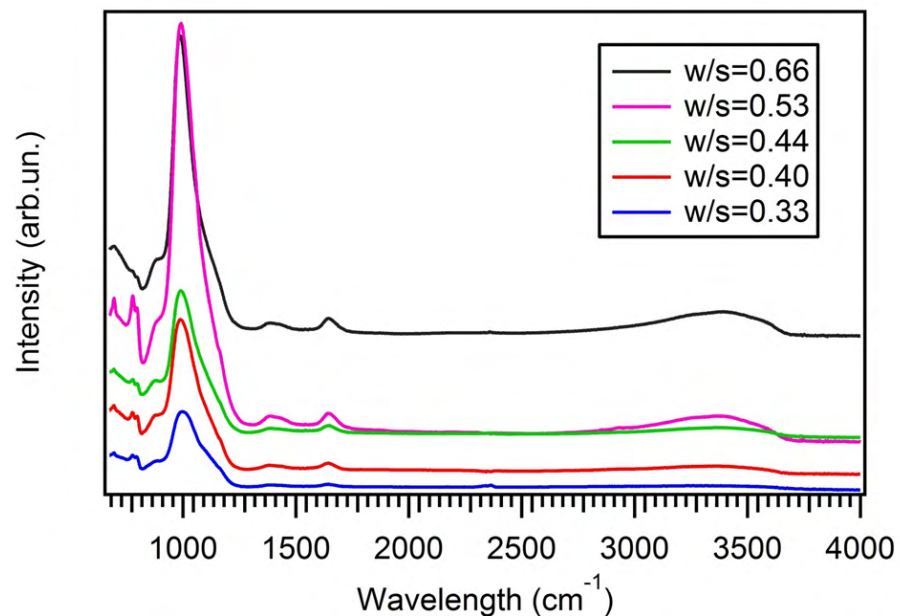


Characterization

XPRD



FTIR-ATR



I. Studies of synthesis parameters



Characterization -SEM-

W/S

0.33

0.40

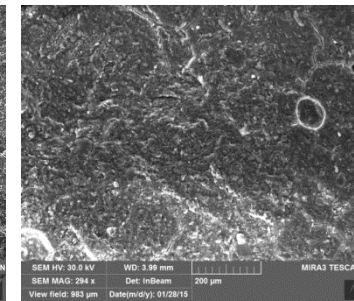
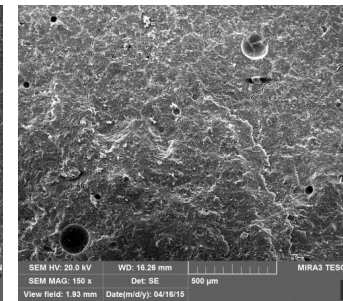
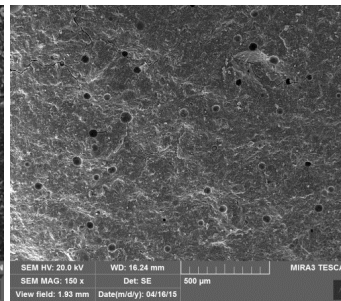
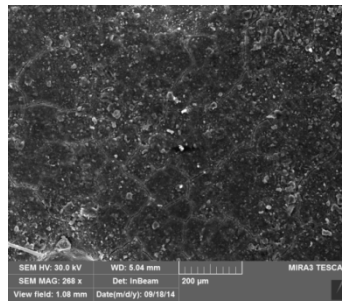
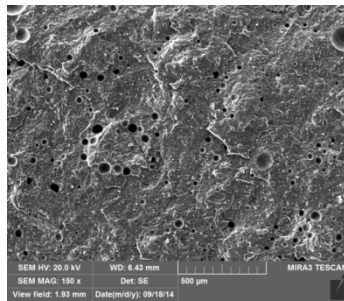
0.46

0.53

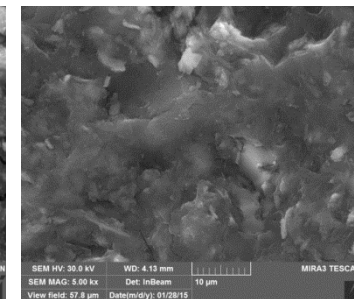
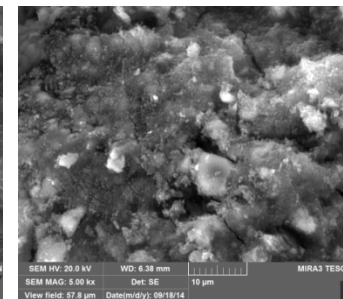
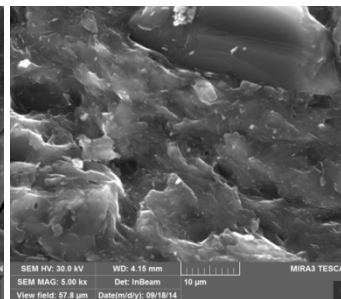
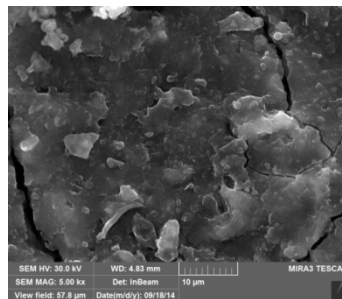
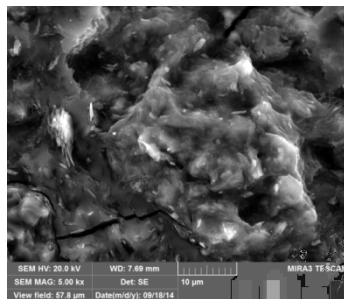
0.60

MAG.

150 x



5000x



I. Studies of synthesis parameters



Characterization -SEM-

W/S

0.33

0.40

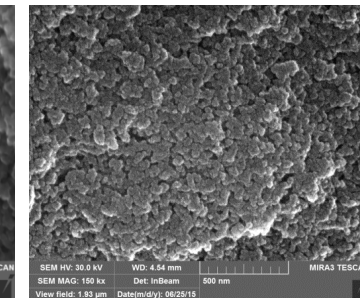
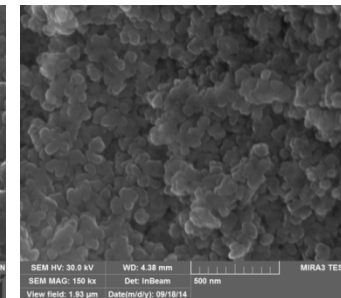
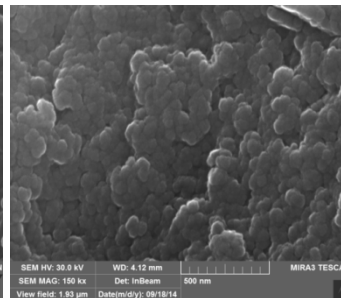
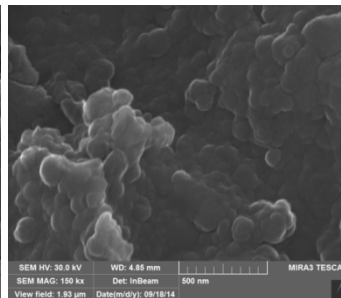
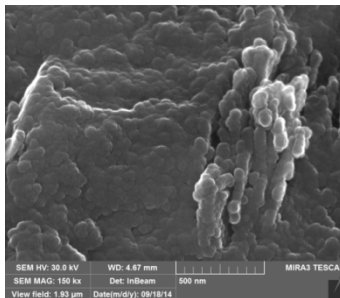
0.46

0.53

0.60

MAG.

150 Kx

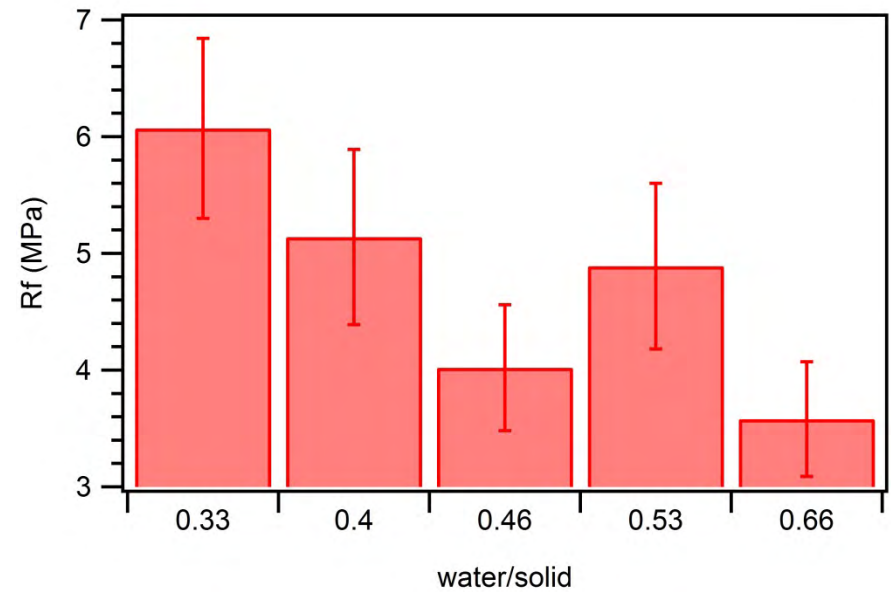
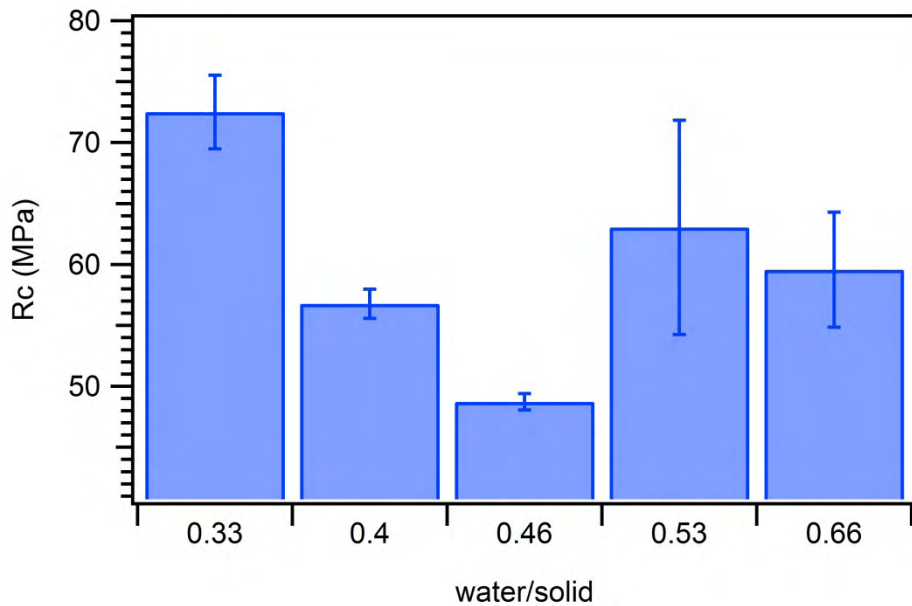


I. Studies of synthesis parameters

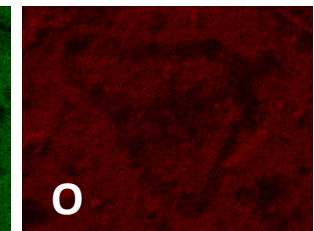
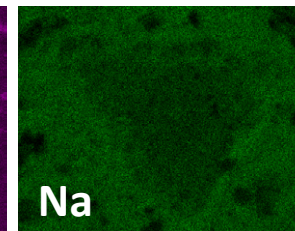
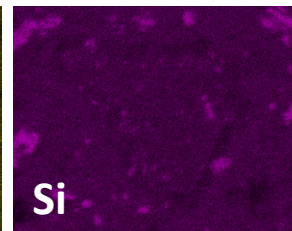
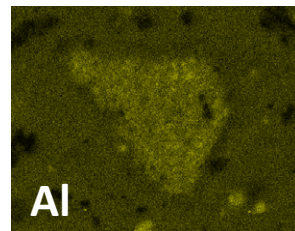
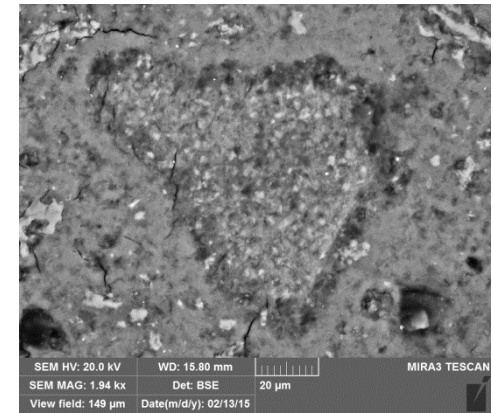
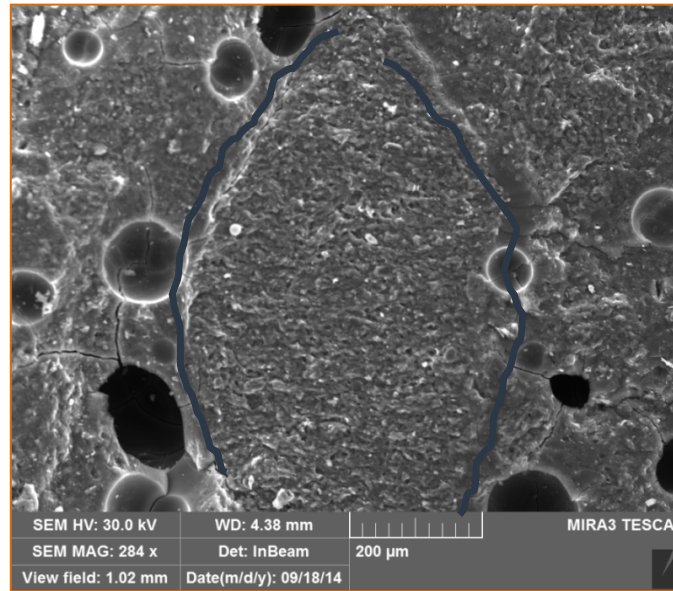
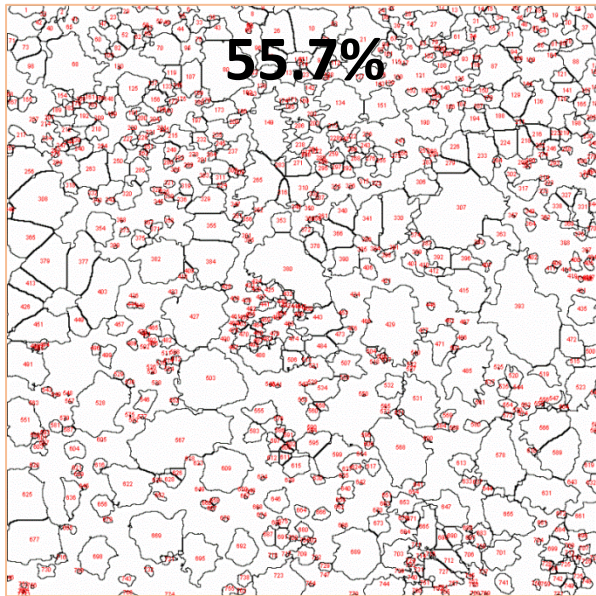


Characterization -*Mechanical test*-

UNI EN 196-1



I. Studies of synthesis parameters



II. Studies for the use of geopolymers to repair historical structures



GOOD FINAL ASPECT

RECOGNIZABLE

GOOD ADHESION TO THE SUBSTRATE

COMPATIBLE

ABSENCE OF HARMFUL BY-PRODUCTS

DURABLE

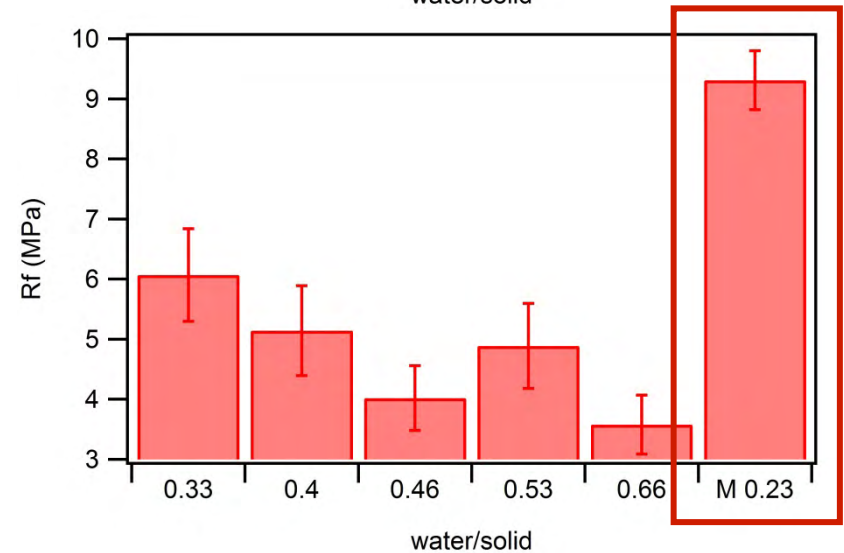
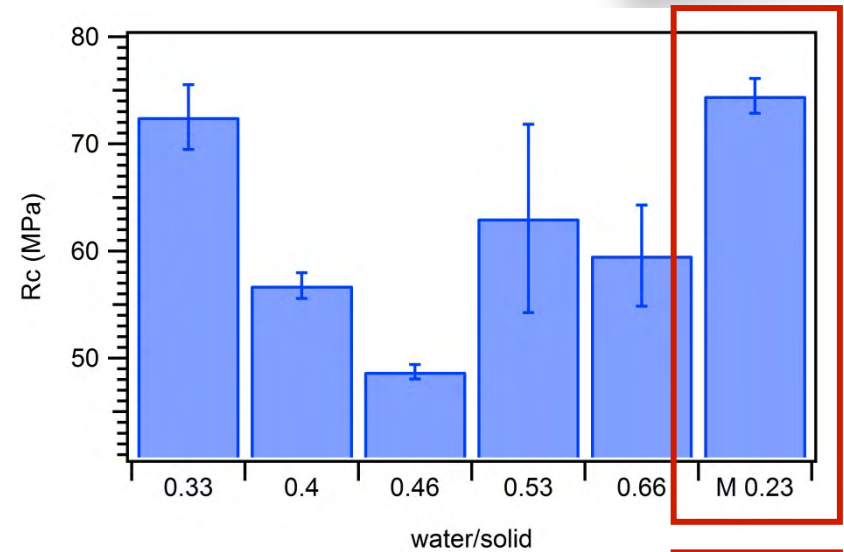
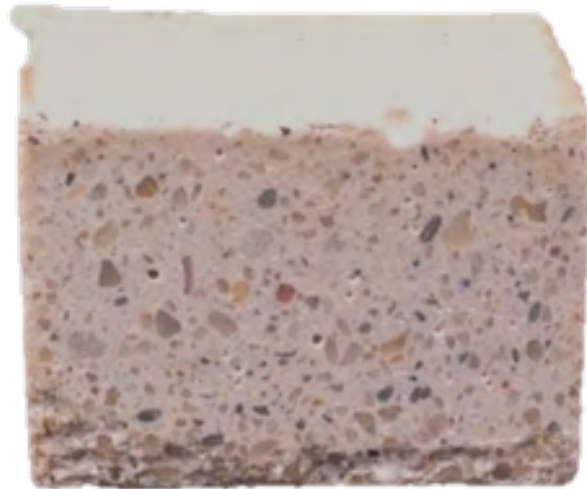
REVERSIBLE



III. Studies for the use of geopolymers to repair historical structures



Mortars



III. Studies for the use of geopolymers to repair historical structures



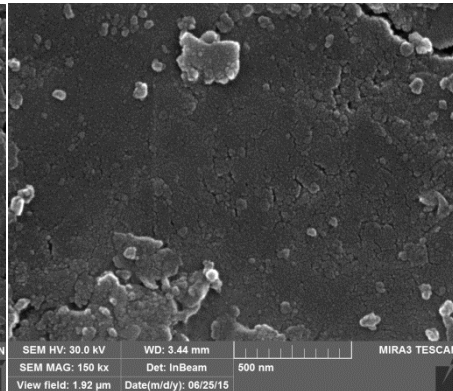
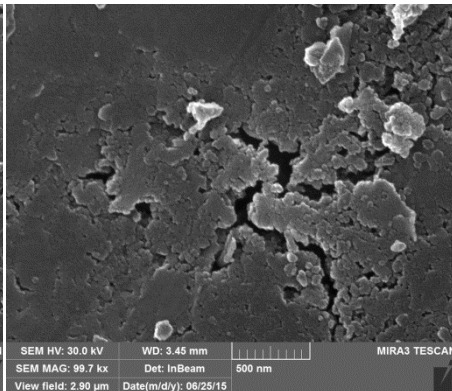
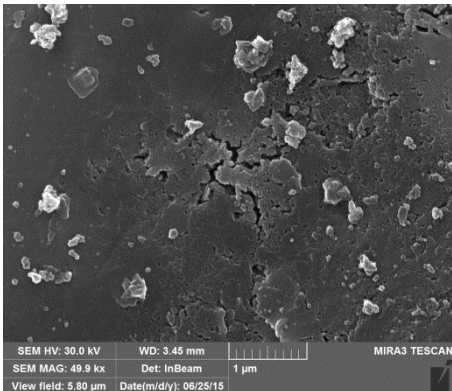
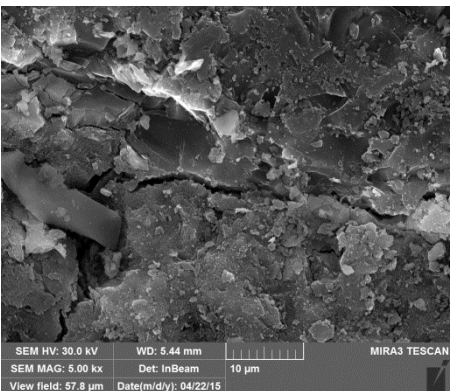
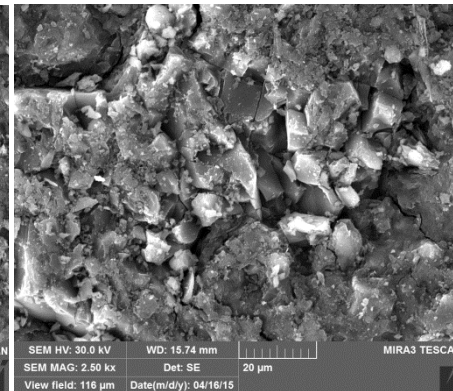
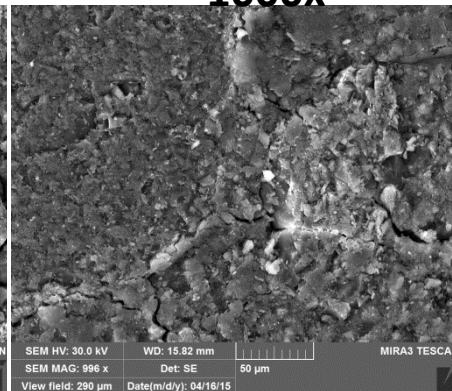
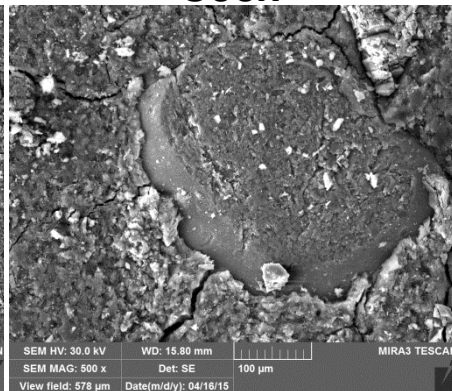
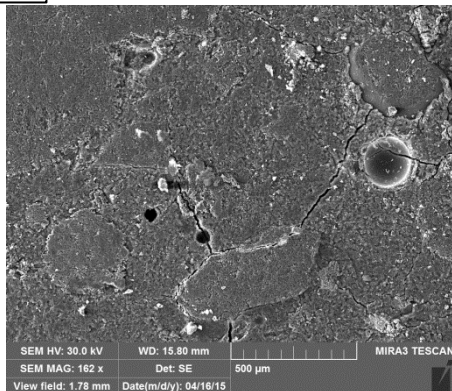
MAG.

150x

500x

1000x

2000x



MAG.

5000x

50 kx

100 kx

150 kx



II. Studies for the use of geopolymers to repair historical structures



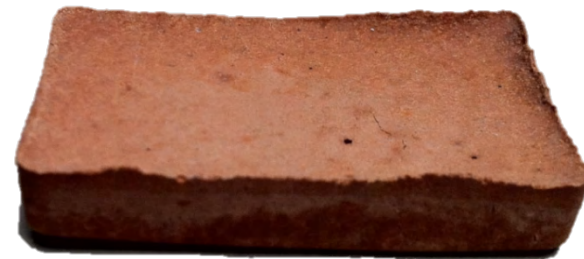
Pietra Serena



Pietra Angera



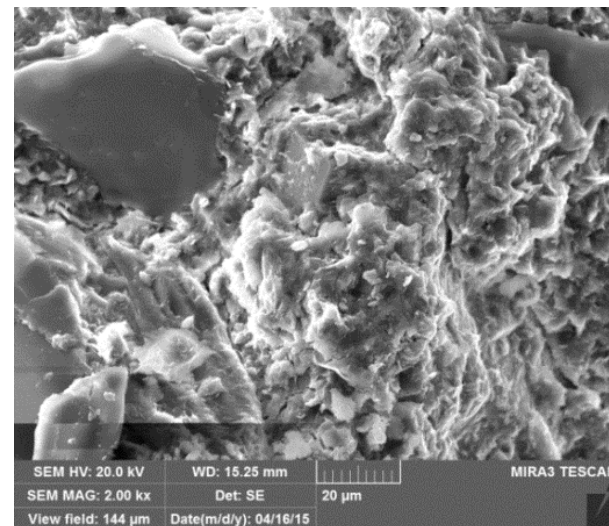
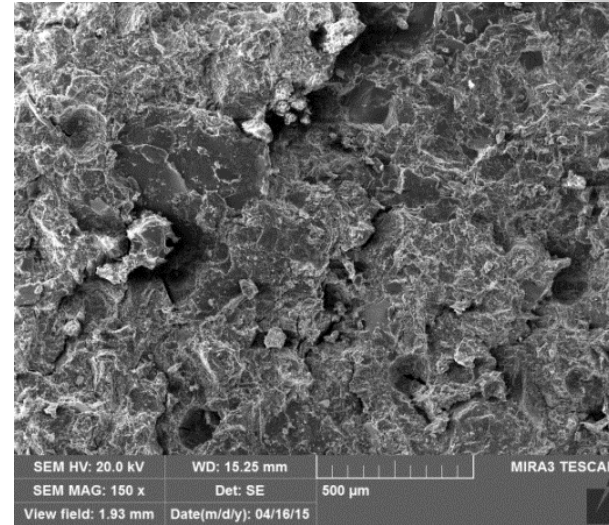
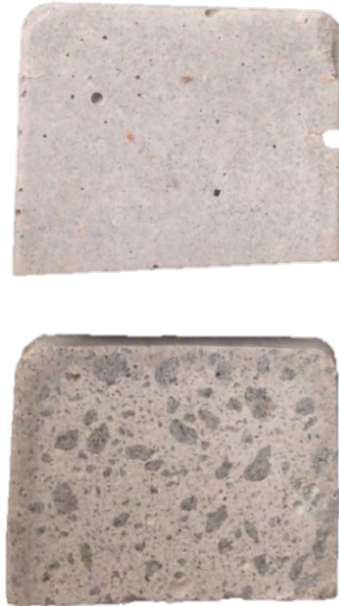
Brick



II. Studies for the use of geopolymers to repair historical structures



Pietra Serena



Adesion values of 1.05 Mpa

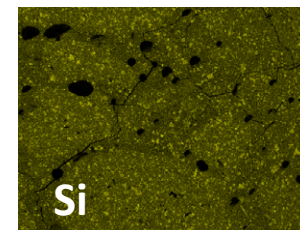
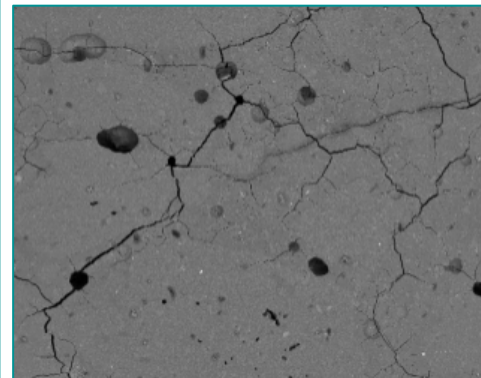
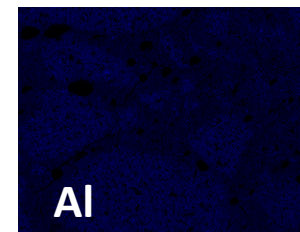
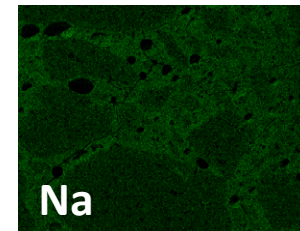
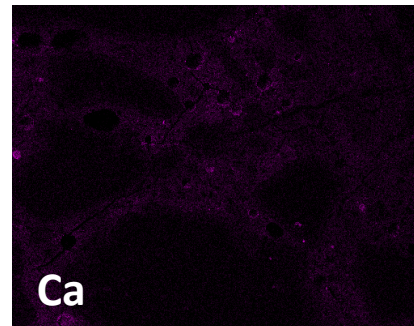
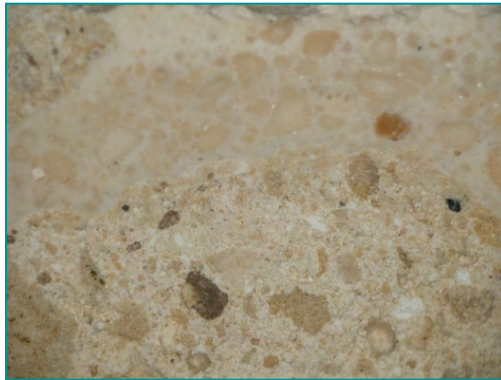
UNI EN 1015-12 -Methods of test for mortar for masonry. Determination of adhesive strength of hardened rendering and plastering mortars on substrates.



II. Studies for the use of geopolymers to repair historical structures



Adhesion to substrate



Conclusions



- The research indicated that geopolymers with an high water content can be used as binder phase in mortar.
- Geopolymers can represent an alternative materials to traditional restoration ones.
- Many aspect as durability, compatibility and the presence of harmful by-product have to be investigate.





Thanks