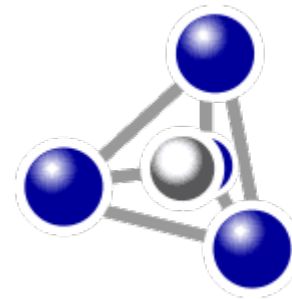
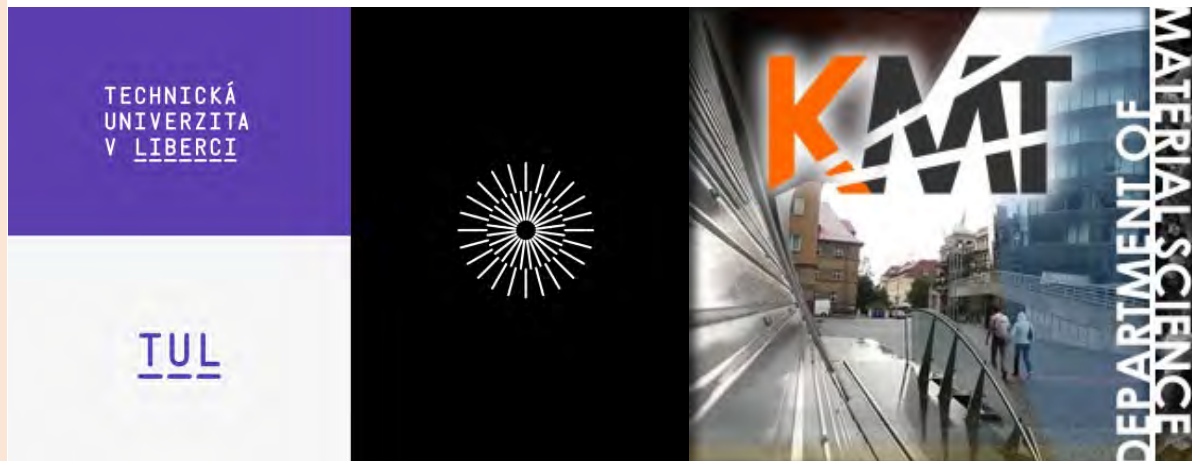


Use of Plasma Incineration Slag as a Filler in Geopolymer Composites

Milan Bouša

Lucie Svobodová, Petr Louda, Piotr Łoś, Baturalp Yalcinkaya, Vojtěch Růžek

TECHNICAL UNIVERSITY OF LIBEREC



GEOPOLYMER
INSTITUTE

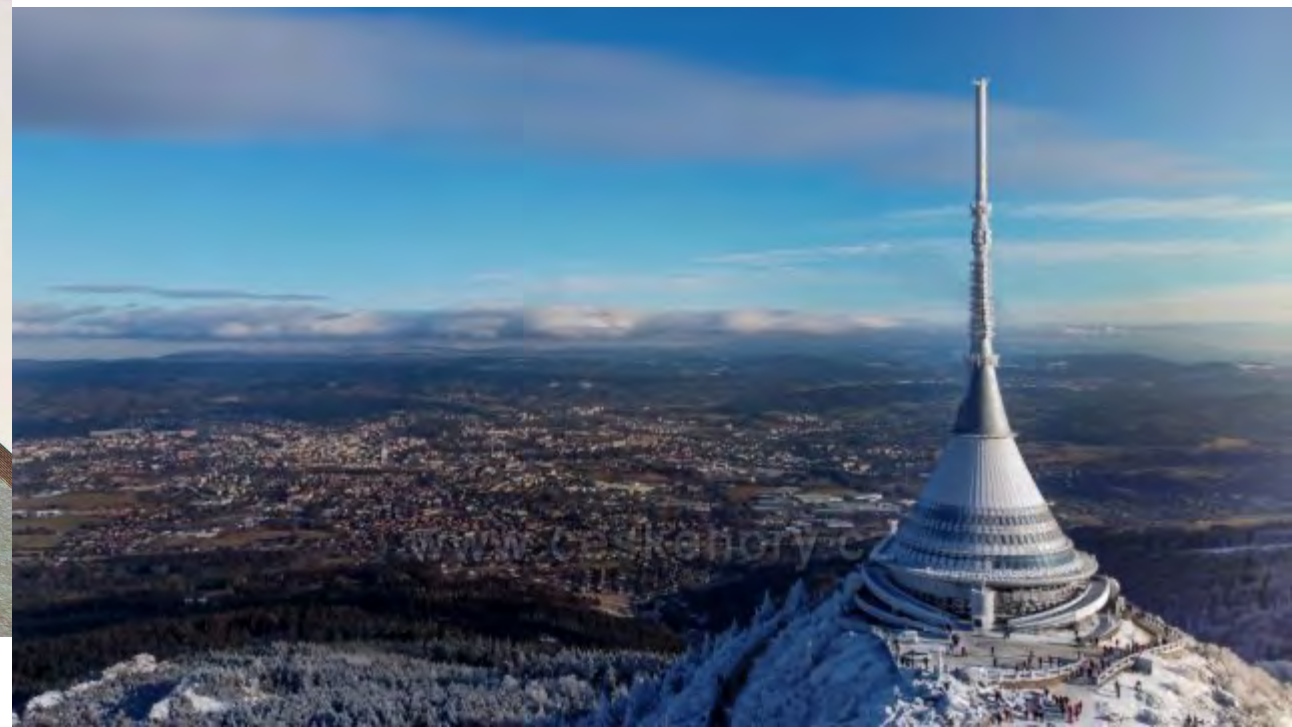
Saint-Quentin 4.-6. July 2022

TECHNICAL UNIVERSITY OF LIBEREC



milan.bousa@tul.cz

JEŠTĚD+LIBEREC



Outline

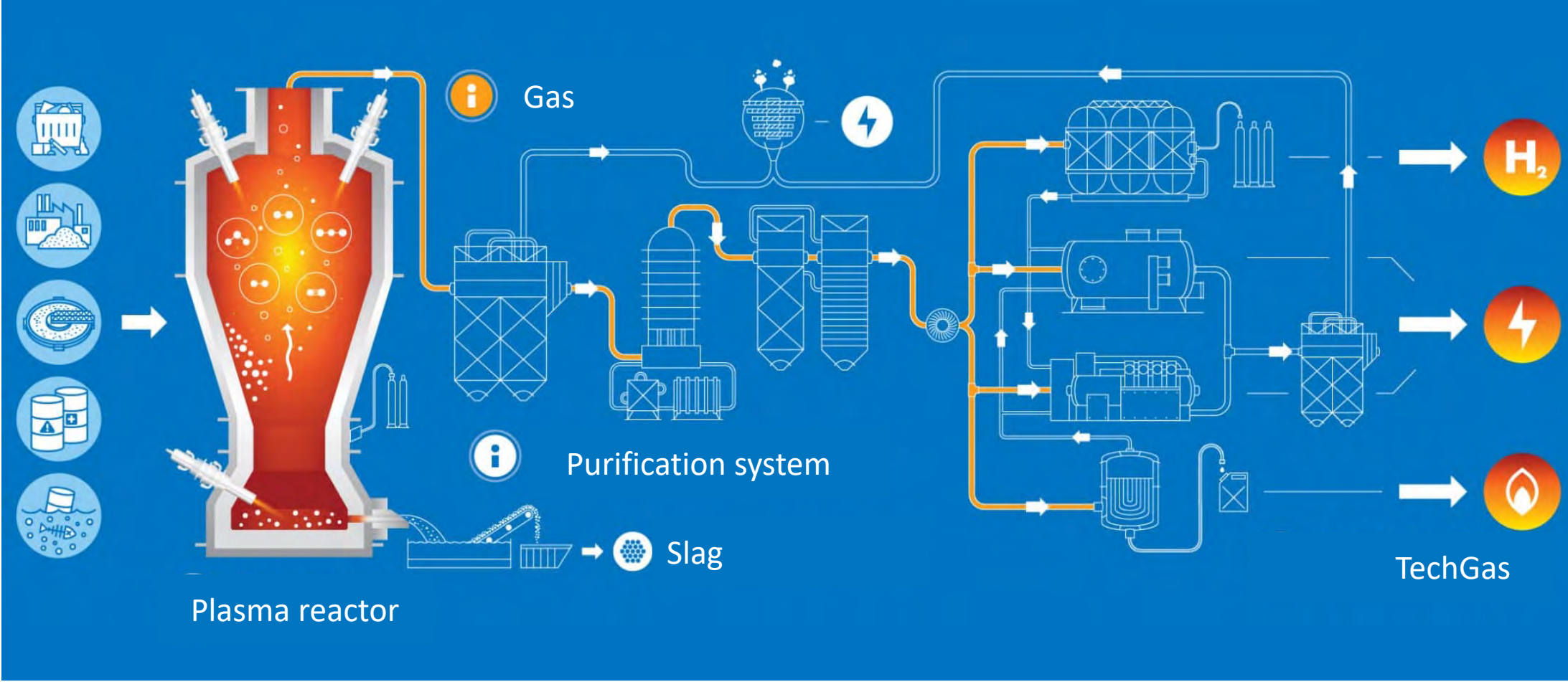
- Plasma Incineration Technology
- Slag Analysis
- Use of Plasma Slag in GP Composite
- Mechanical and Physical properties of GP Composite
- Environmental Evaluation of GP Composite

Plasma Incineration

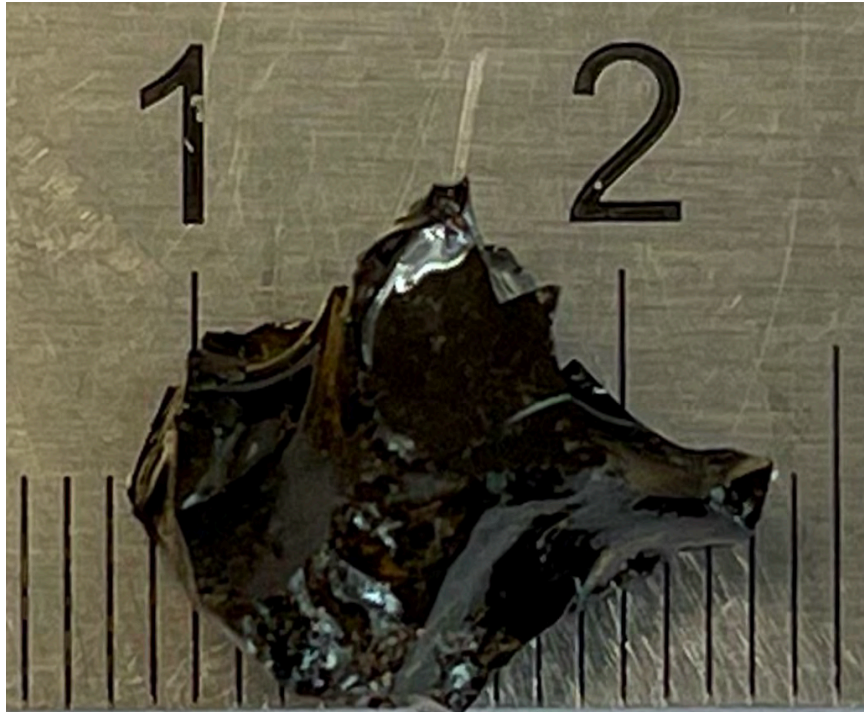
- plasma gasification 
- plastics, industrial waste, dangerous and hospital wastes, communal waste, sewage sludge, covid-waste     
- plasma up to 3000 – 5000°C
- TechGas + **slag**
- electricity production
- mobile unit 



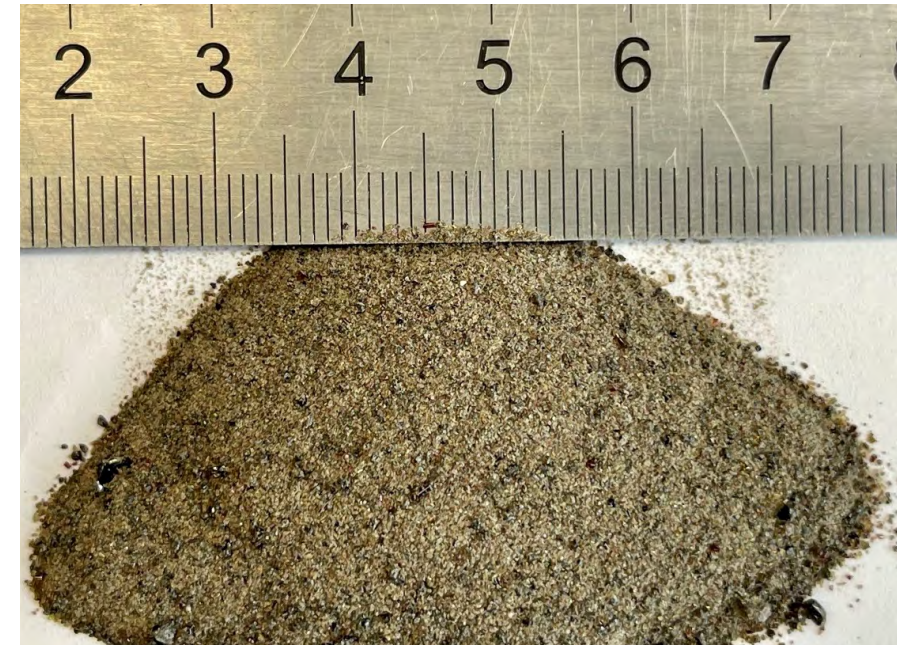
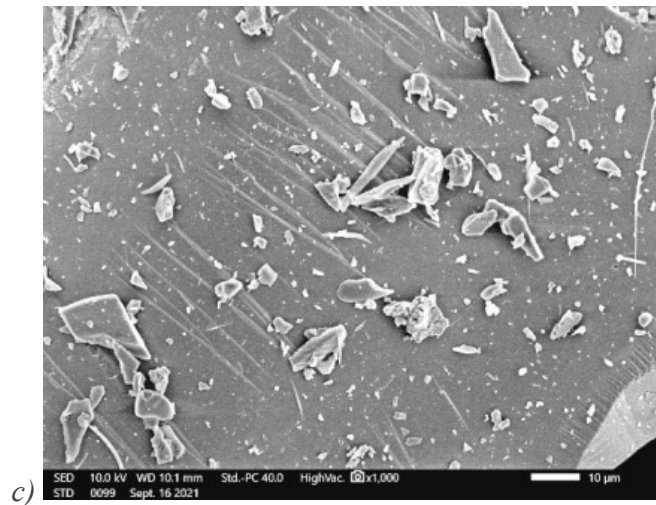
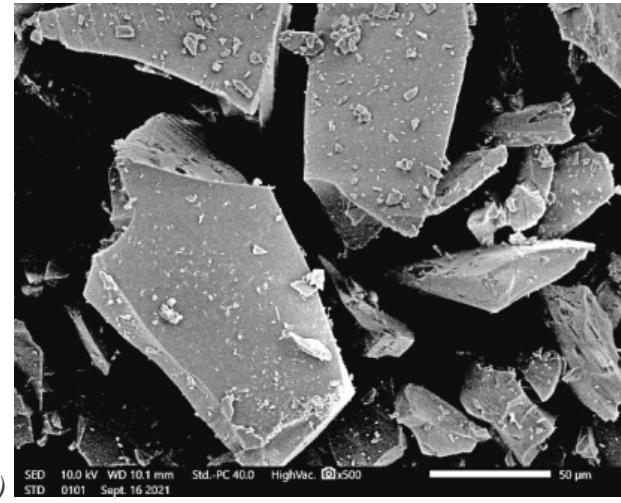
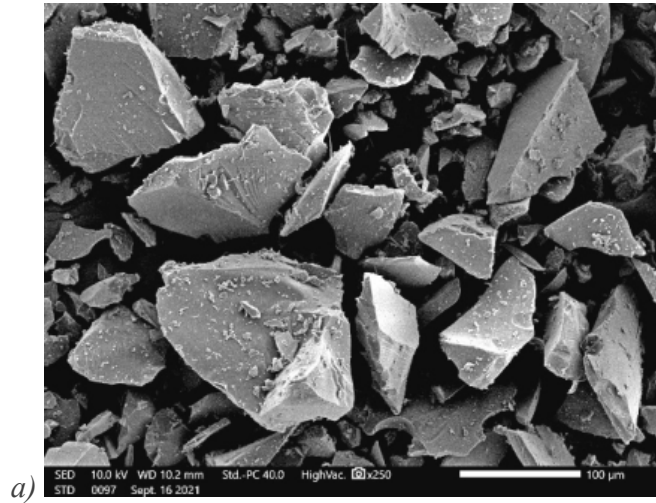
Plasma Incineration



Plasma Incineration Slag

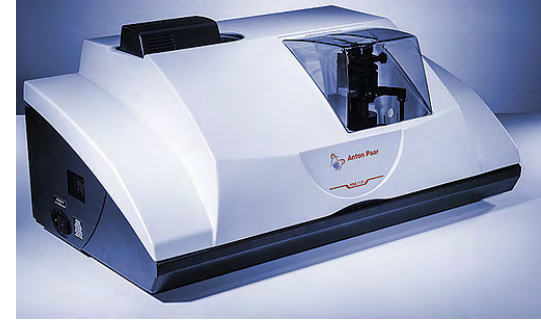


SEM of Ground Slag

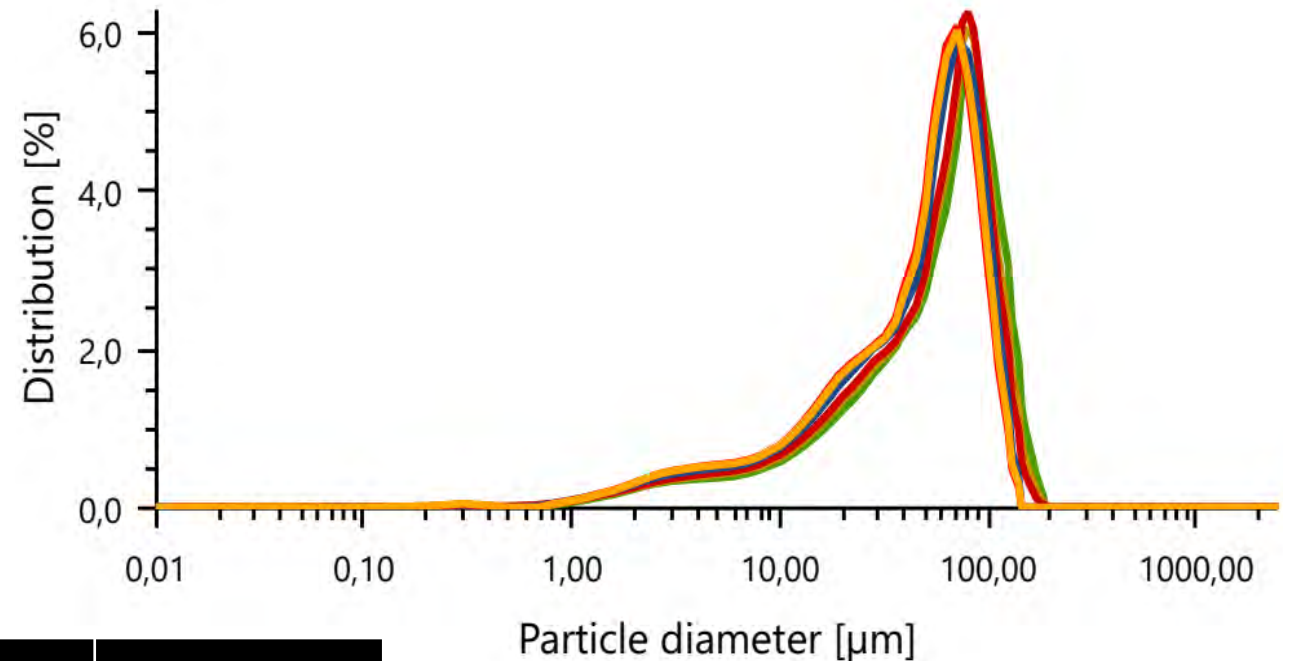


Particle Size Analysis

PSA 1190 LD (Anton Paar)
particle analyzer

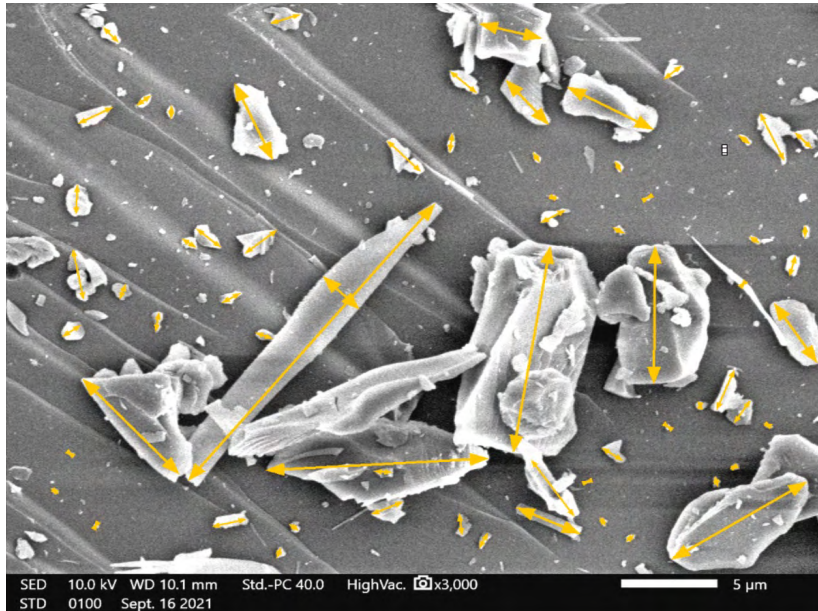


- A sample of ground vitrified slag was dispersed into the liquid and then characterized.
- The graph shows the particle size distribution; the x-axis is in logarithmic scale.
- The table shows the characterisation of the particles:

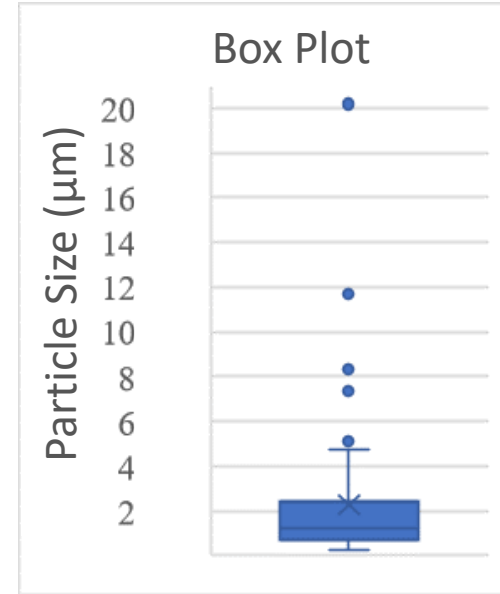
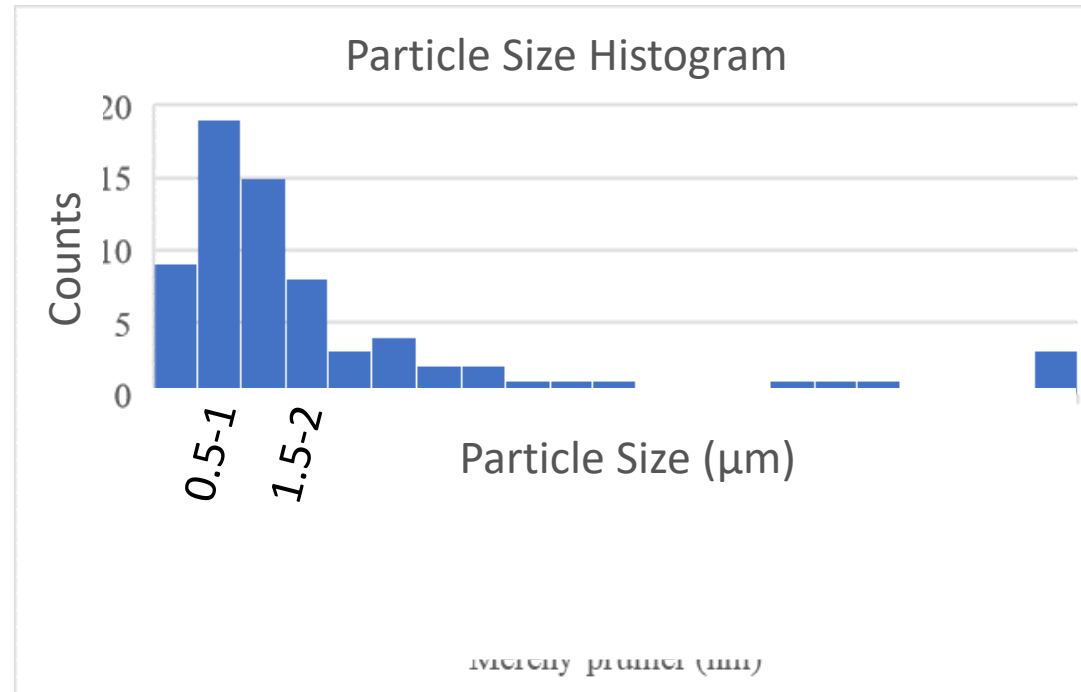


	Bottom 10% (µm)	Bottom 50% (µm)	Bottom 90% (µm)	Average size (µm)
Average (µm)	7.9	52.9	97.5	55.1
Deviation (µm)	0.9	4.2	7.4	4.4

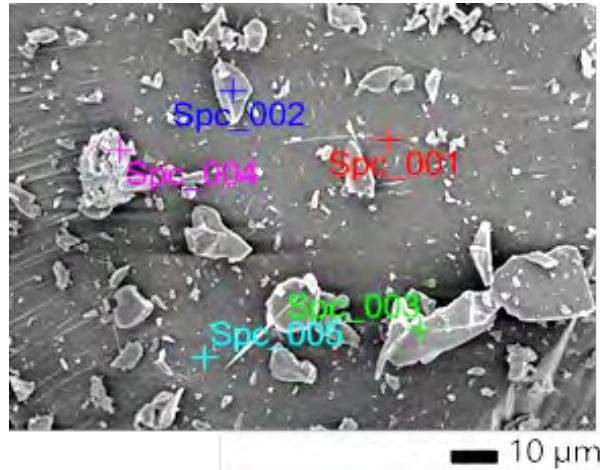
Small Particle Size Analysis



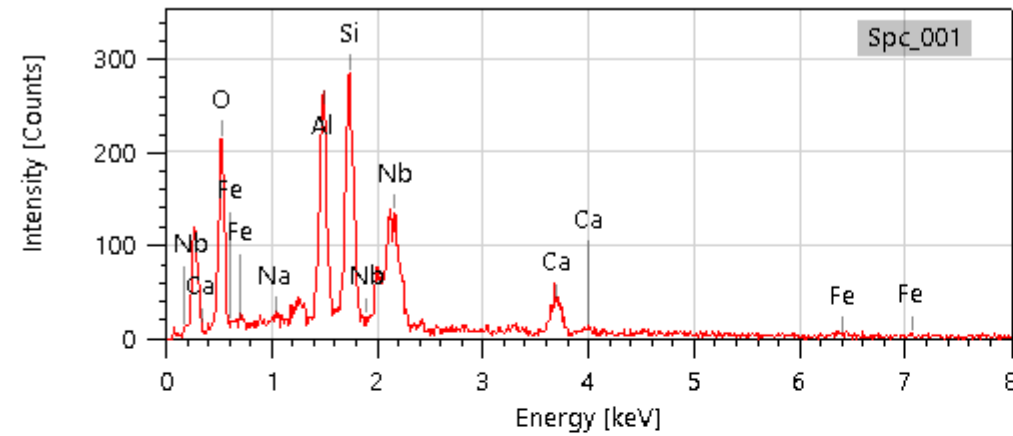
Average = 2.3 μm
Median = 1.2 μm



EDS Elemental Analysis

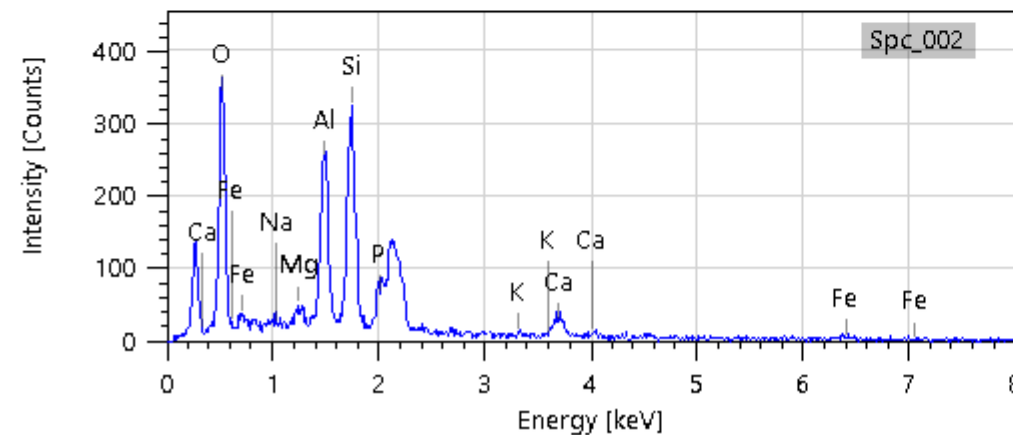


Spc_001



Element	Line	Mass%	Atom%
O	K	27.1 ± 1.1	46.6 ± 1.9
Na	K	0.5 ± 0.1	0.6 ± 0.2
Al	K	15.6 ± 0.7	15.9 ± 0.7
Si	K	21.1 ± 0.9	20.7 ± 0.9
Ca	K	11.3 ± 1.1	7.7 ± 0.8
Fe	K	5.4 ± 2.1	2.6 ± 1.0
Nb	L	18.6 ± 1.5	5.5 ± 0.4

Spc_002

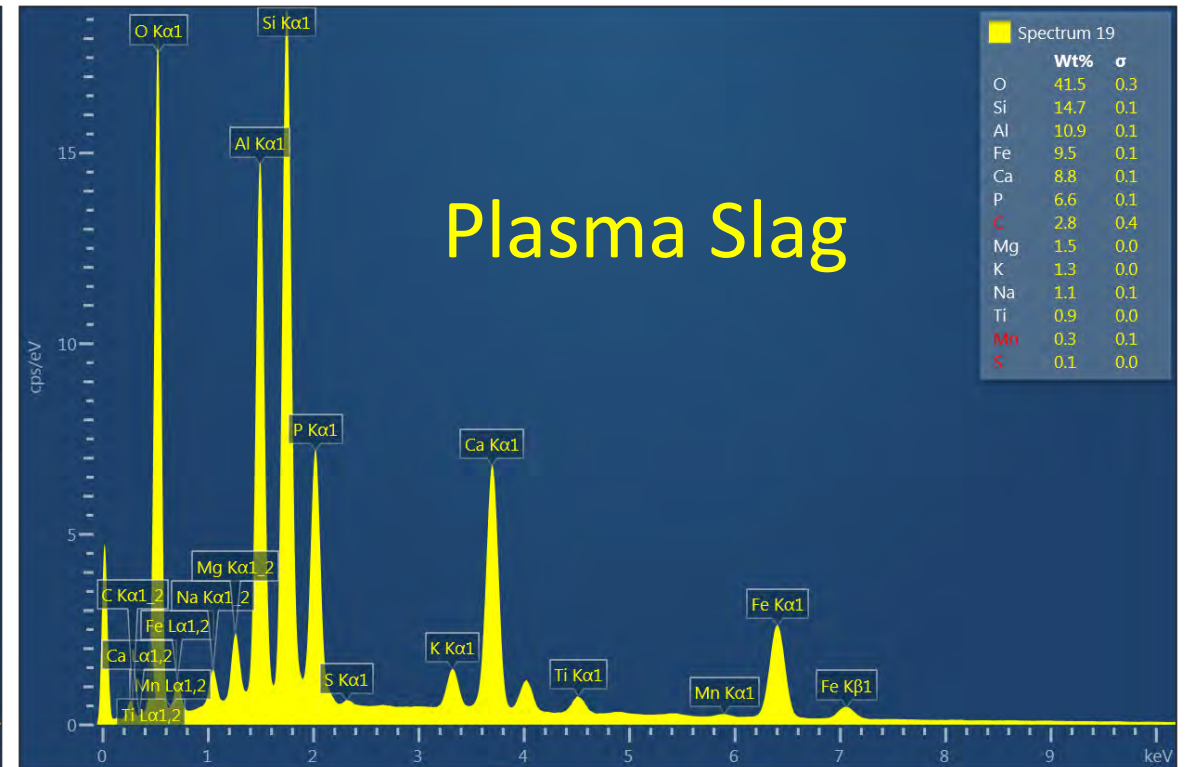
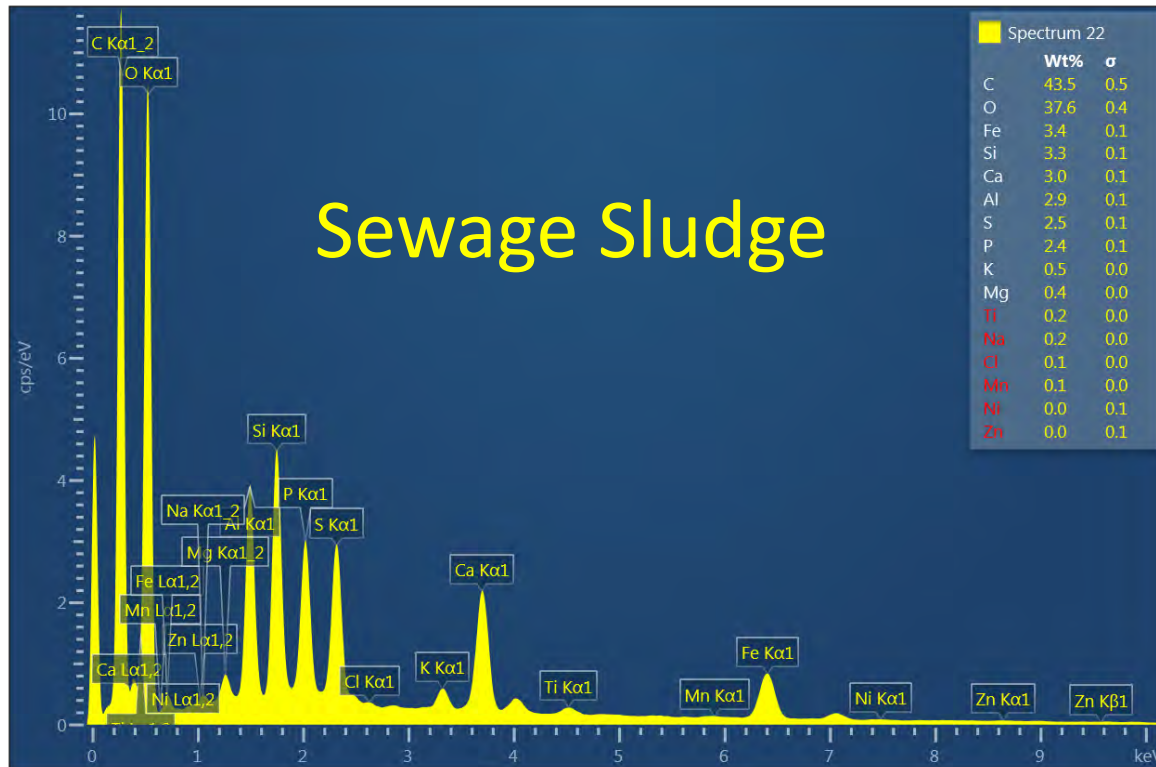


Element	Line	Mass%	Atom%
O	K	36.3 ± 1.2	52.6 ± 1.7
Na	K	0.2 ± 0.1	0.2 ± 0.1
Mg	K	1.5 ± 0.2	1.4 ± 0.2
Al	K	16.4 ± 0.8	14.1 ± 0.6
Si	K	25.2 ± 1.0	20.8 ± 0.9
P	K	1.9 ± 0.4	1.4 ± 0.3
K	K	1.2 ± 0.4	0.7 ± 0.2
Ca	K	8.5 ± 1.0	4.9 ± 0.6
Fe	K	8.3 ± 2.5	3.4 ± 1.0

EDS Elemental Analysis

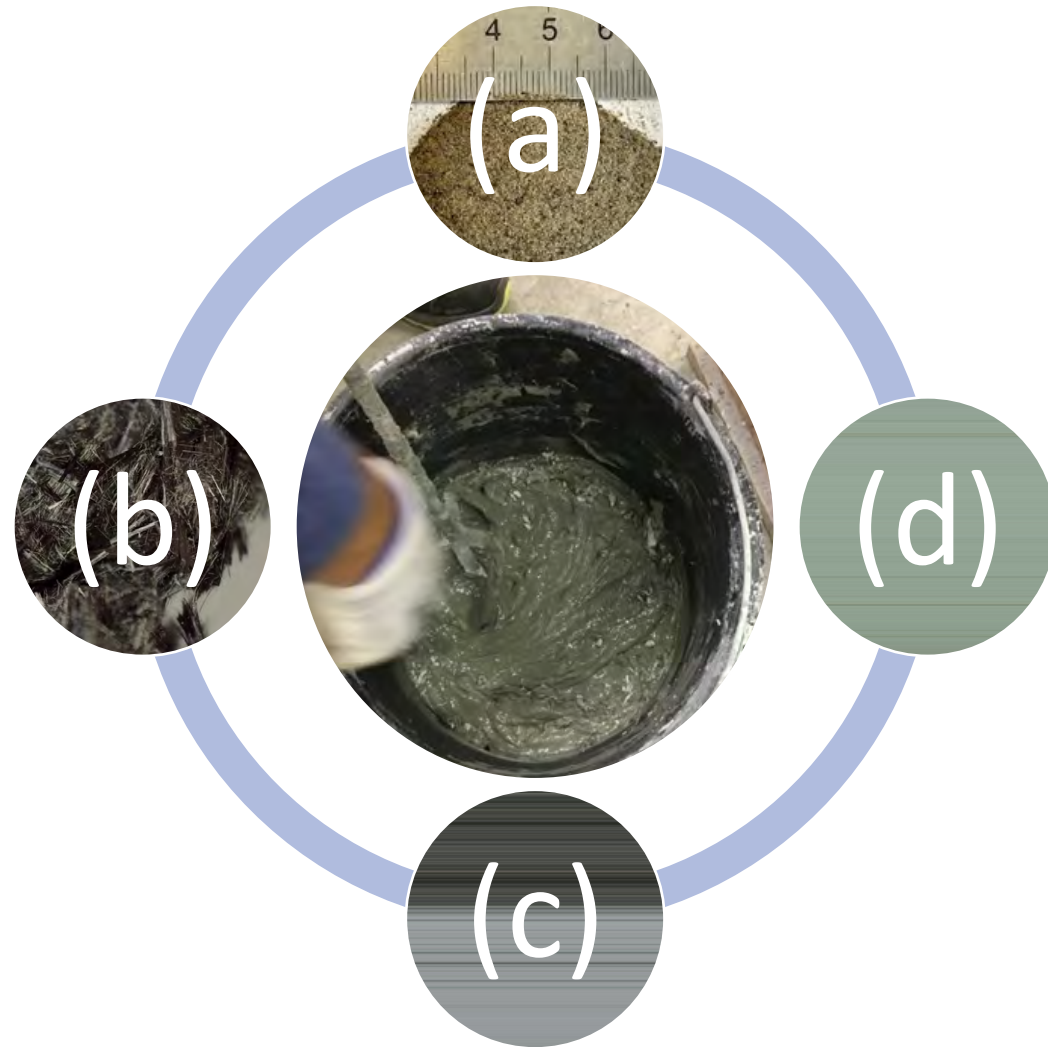
Analysis of the elemental composition of the vitrified slag revealed mainly the following elements:

- Calcium, Iron, Potassium, Magnesium, Sodium, Oxygen, Phosphorus, Silicon
- Aluminium, (Chromium), Niobium



Geopolymer Preparation

- (i) Metakaolin was mixed with alkaline potassium hydroxide solution for five minutes.
- (ii) Ground **SLAG** (A), chopped carbon fibre (B), silica fume (C), and chamotte (D) were added.
- (iii) Mixed for five minutes and finally the fresh mixture was poured into the mould.

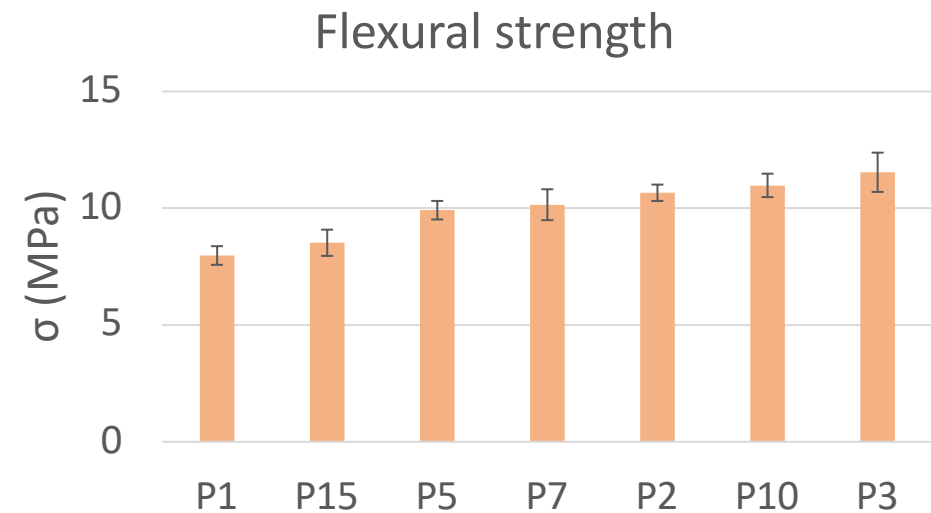
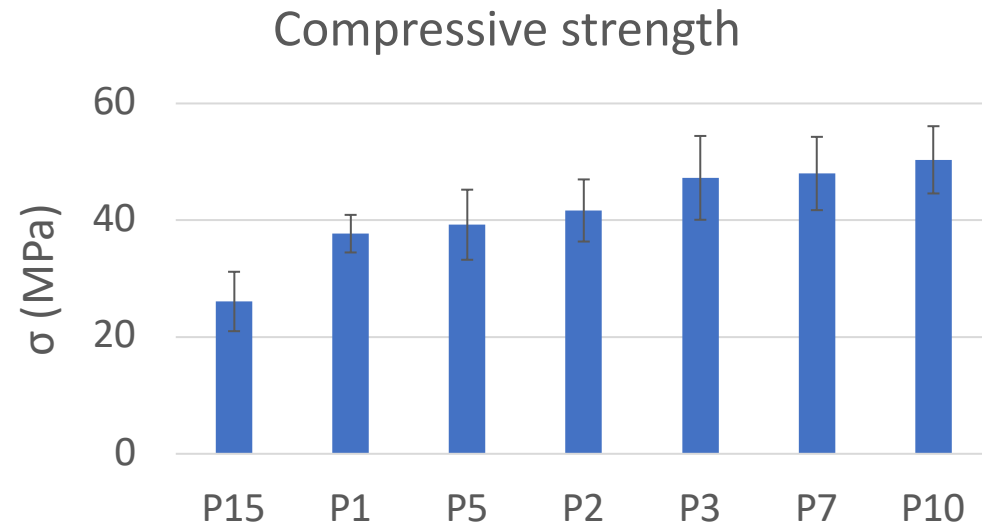




Evaluation of Selected Mechanical Properties of Composite - *Compressive and Flexural Strength*

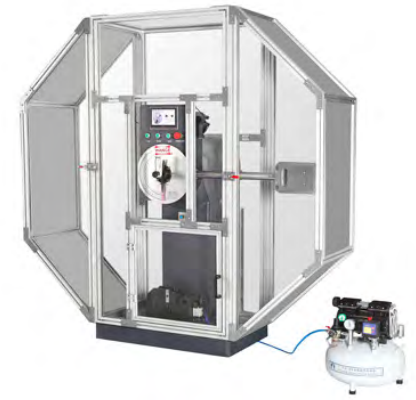
Name of the Sample: P = Plasma slag addition

number = ratio Slag to Metacaolin in % (weight)

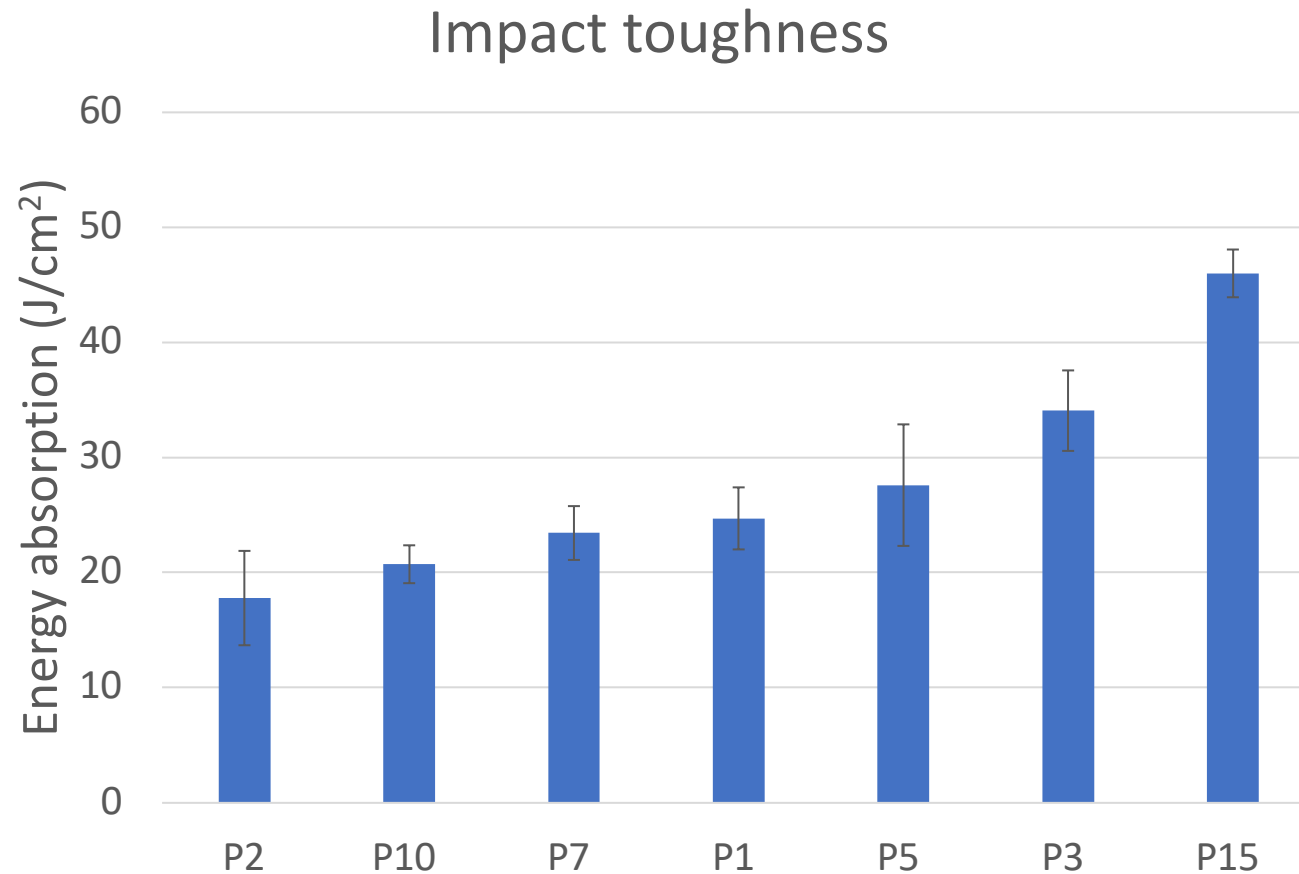


Evaluation of Selected Mechanical Properties of Composite

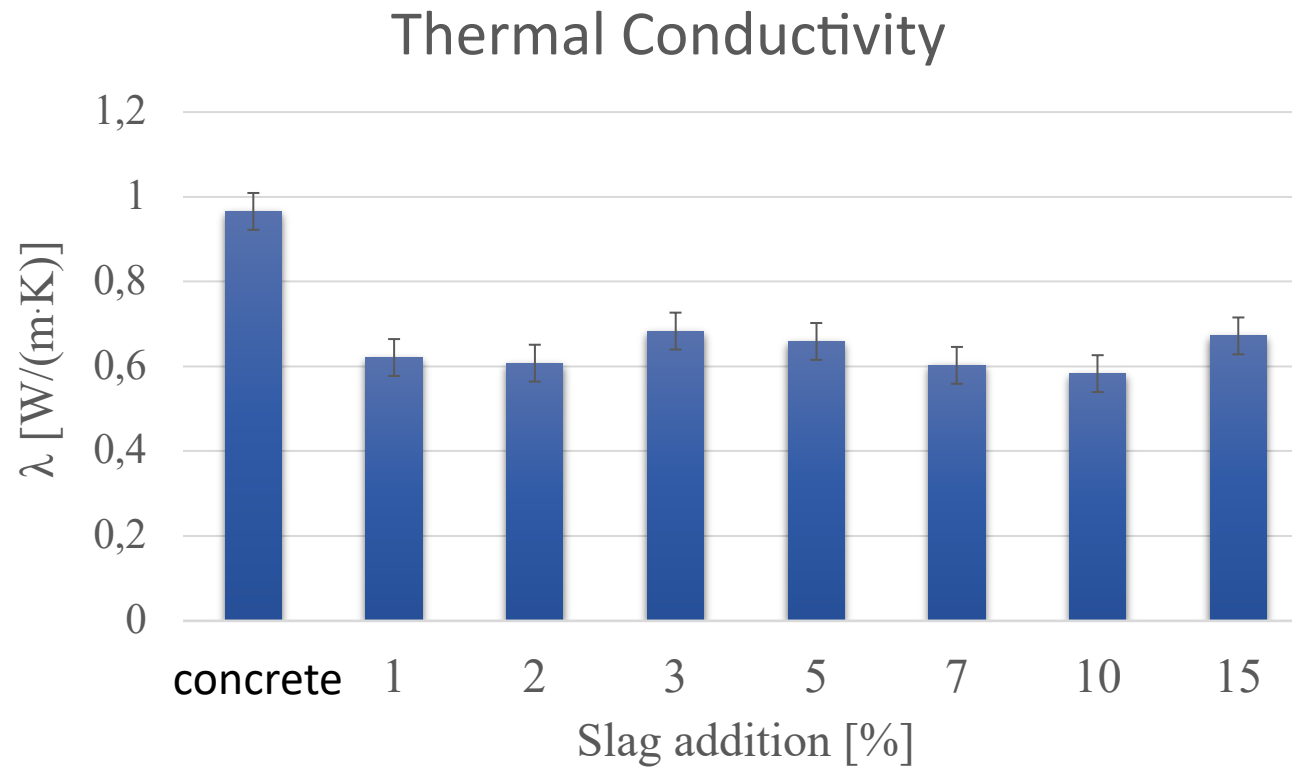
- *Impact toughness*



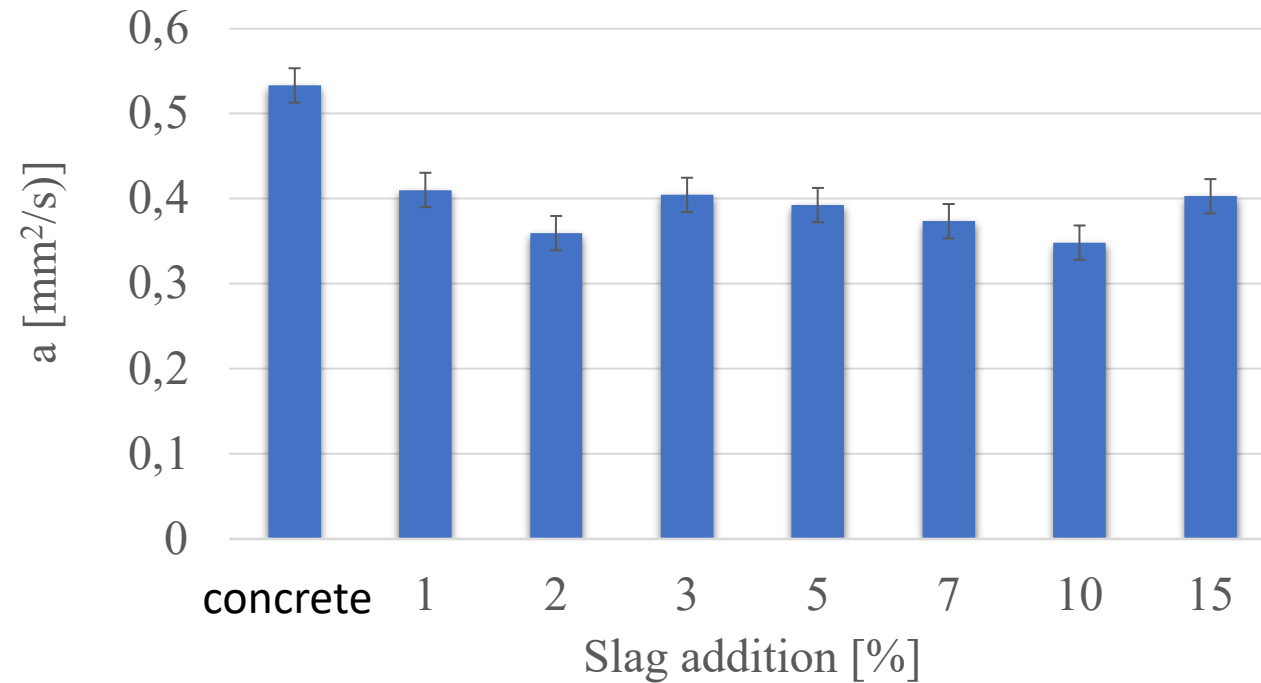
Wance Pendulum
impact test machine



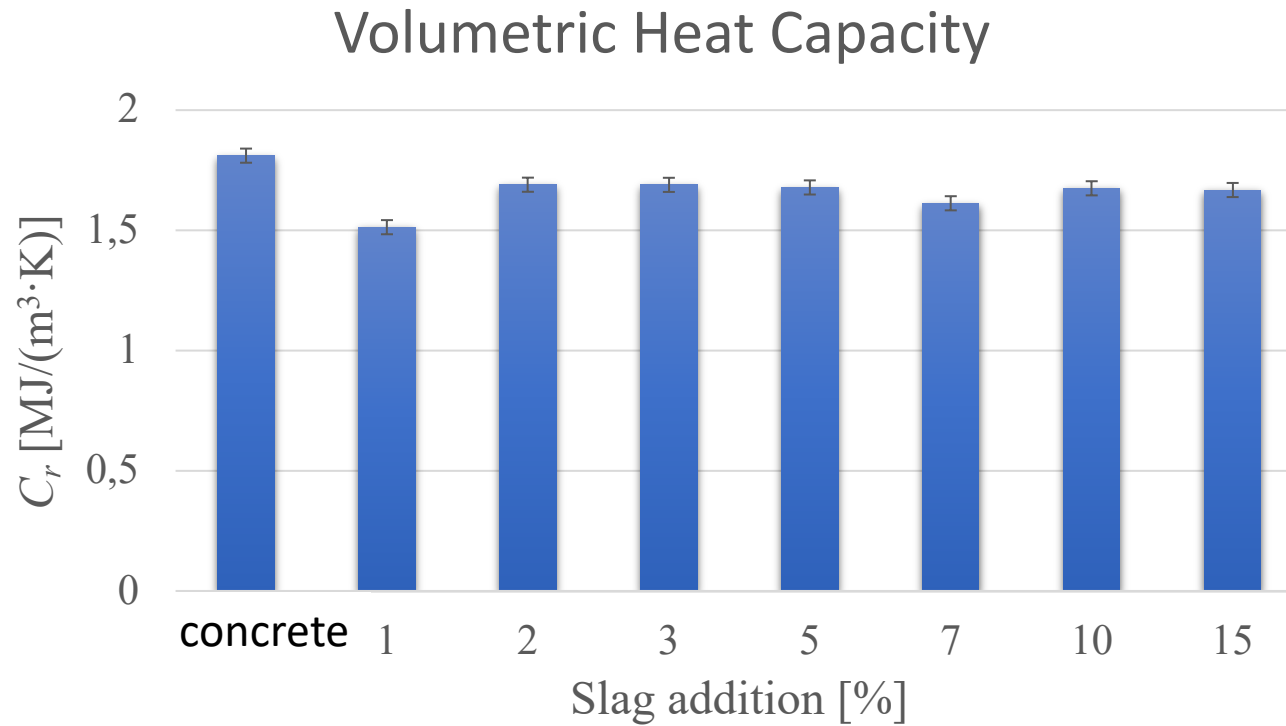
Evaluation of Selected Physical Properties of Composite - *Thermal Conductivity*



Evaluation of Selected Physical Properties of Composite - *Thermal Diffusivity*



Evaluation of Selected Physical Properties of Composite - *Volumetric Heat Capacity*



Evaluation of Selected Physical Properties of Slag - *Leaching Test*

- According to EN 12457-1: Waste characterisation - Leaching, Verification test for leachability of granular wastes and sludges.
- Mixing is carried out for 24 hours. Analysis by ICP-MS Nexlon 300D from Perkin Elmer.

- (1) DI water
- (2) HNO₃ (1 ± 0,1 mol/l)
- (3) HNO₃ (pH = 4 ± 0,1)
- (4) acetic acid (pH = 2,88)















Sample	Al (mg/kg)	As (mg/kg)	Cr (mg/kg)	Nb (mg/kg)	Pb (mg/kg)	Sample	Temp. [°C]	pH	ORP [mV]	Conduct. [μS/cm]
1	0,4	<0,01	<0,01	<0,01	<0,01	1	21,5	7,0	273	135
2	346,4	0,6	71,2	0,9	0,4	2	21,5	2,6	518	56 000
3	44,3	0,2	0,4	<0,01	<0,01	3	21,5	3,9	230	1 080
4	2,0	<0,01	<0,01	<0,01	<0,01	4	21,5	7,0	235	155

Evaluation of Selected Physical Properties of Slag - *Antibacterial Activity*

Evaluation of slag for potential antibacterial activity.

- No significant antibacterial activity in the non-milled slag sample.
- Moderate antibacterial activity for the ground slag sample (55 μm) for all leachates tested.

The slag in the form of large particles CAN BE STORED safely without risk!!!

	DI water	Physiological Solution	Acetic Acid
<i>Staphylococcus spp.</i>			
Non-milled			
Milled			
<i>Micrococcus luteus</i>			
Non-milled			
Milled			

Summary

- Plasma Incineration Technology
 - Source of energy, waste disposal
 - Slag as a filler
- Slag Analysis
- Use of Plasma Slag in Composite
- Mechanical and Physical properties of Composite
- Environmental Evaluation of Composite
 - No significant antibacterial activity
 - Low leaching

TECHNICAL
UNIVERSITY
OF LIBEREC

THANK YOU FOR YOUR
ATTENTION!

**This work was supported by the Student Grant
Competition of the Technical University of Liberec
under the project No. SGS-2022-5066**



milan.bousa@tul.cz