

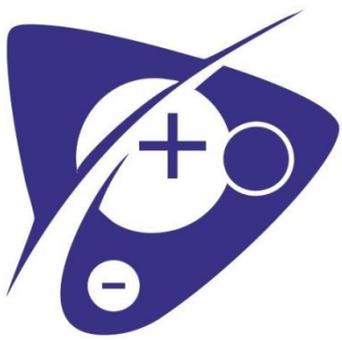
EFRE 2020

Synthesis of Clinker Minerals in Highly-Concentrated Thermal Flux

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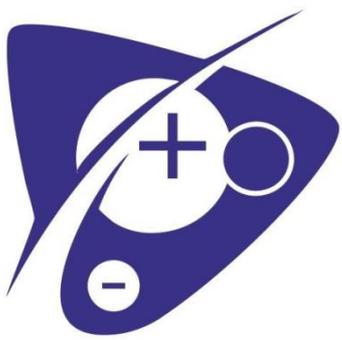
Tomsk State University of Architecture and Building

2020



RAW MIX COMPONENTS

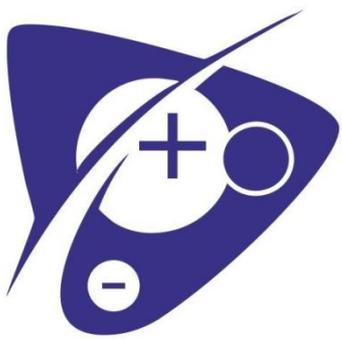
Types of mix composition	Raw mix composition, wt.%			
	Marble	Fly ash	Quartzites	Purple ores
A-1	83.90	11.70	1.55	2.85
A-2	81.88	13.07	1.69	3.36
	Dolomitic limestone grinding waste	Flotation waste		Limestone
B-1	83.57	11.90		4.53
B-2	81.31	14.67		4.02



Obtaining of the cement clinker

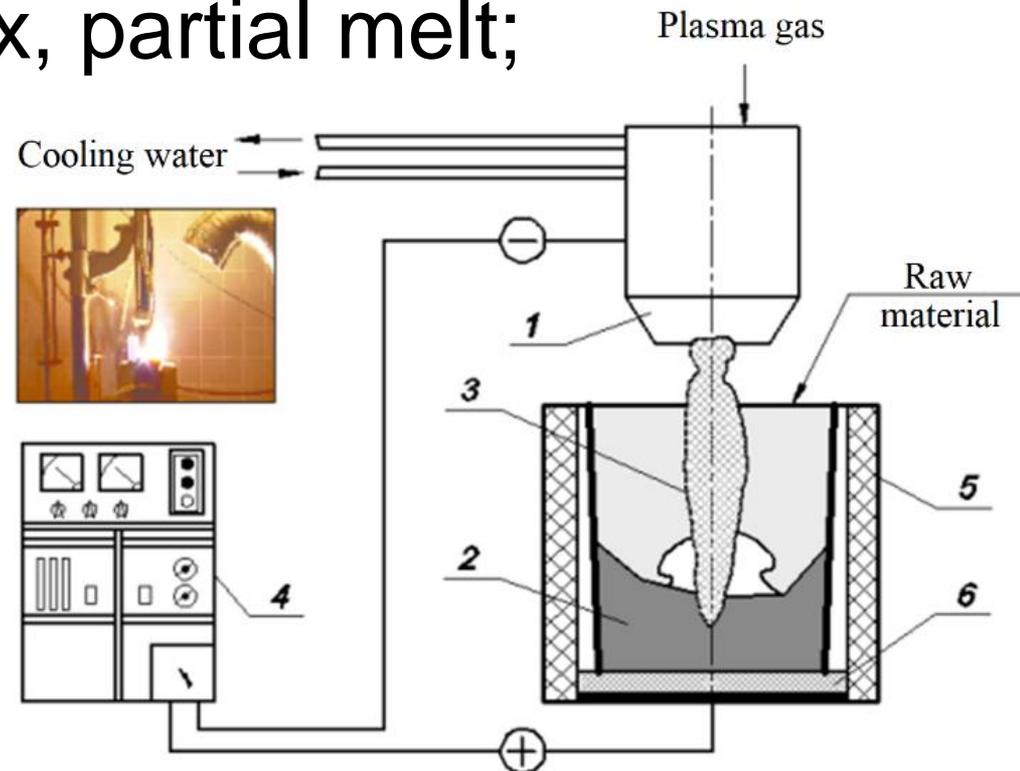
The mix preparation included several stages, such as

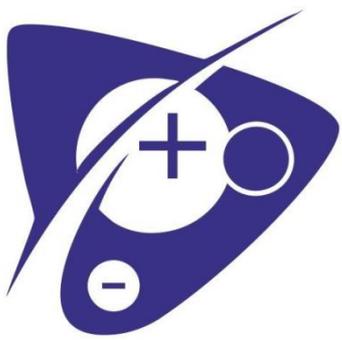
- dosing;
- crushing;
- grinding of components in a ball mill ShLM–5 to obtain 0.16 mm particles;
- homogenizing of dry components and subsequent granulation in an R-009 granulating machine down to 5 mm particle size.
- Thermal treatment of the granular mix was performed on the laboratory setup. This thermal generating unit comprised a plasma torch and a furnace with enclosed volume.



Experimental laboratory setup for low-temperature plasma treatment

- 1 – plasma torch;
- 2 – granular raw mix, partial melt;
- 3 – plasma arc;
- 4 – power supply;
- 5 – furnace;
- 6 – anode.

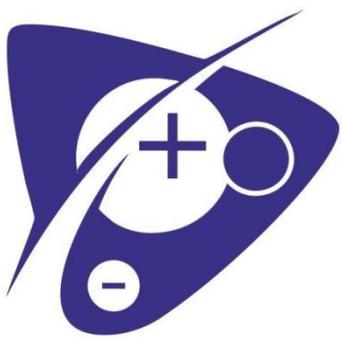




Investigation of the obtained cement clinker

Includes:

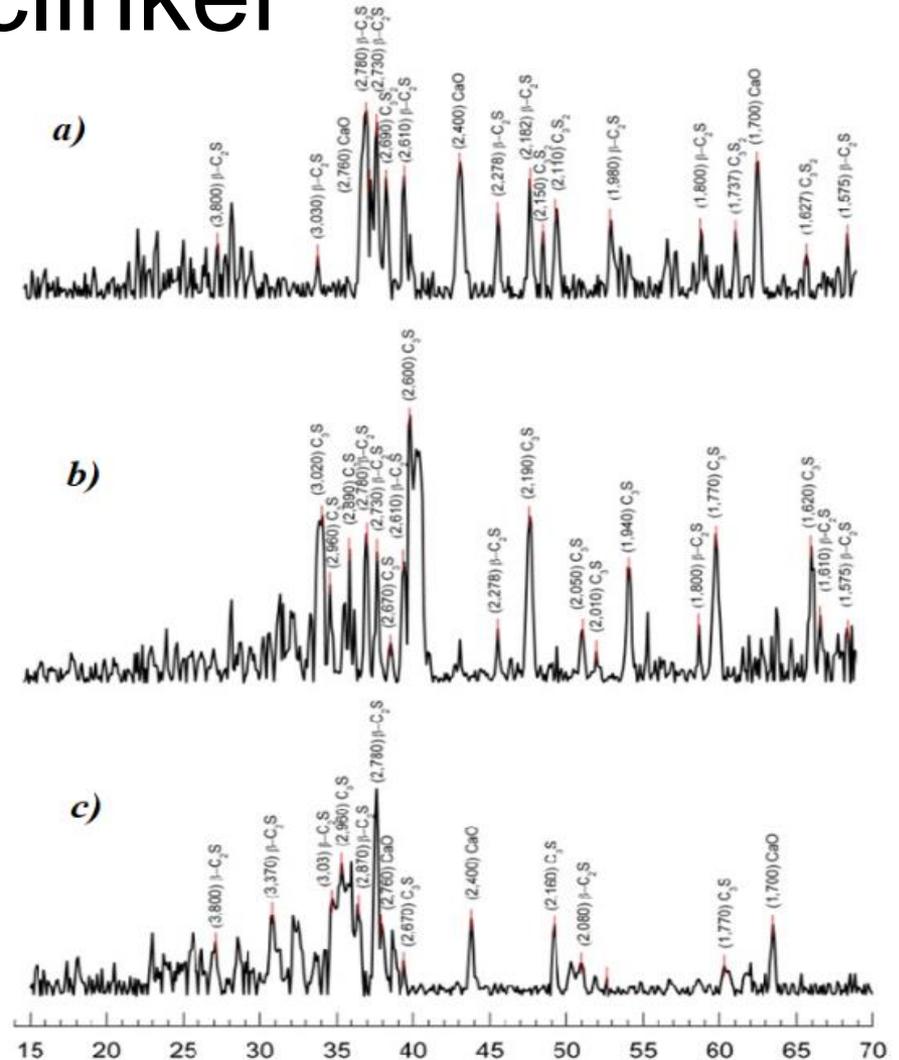
- X-ray diffraction analysis (XRD) carried out by DRON-8 diffractometer (Russia);
- Differential thermal analysis (DTA) made on a Q-1500 D derivatograph (MOM, Hungary);
- A Metkon GEOLINE petrographic cutting machine (Turkey) was used for petrographic sample preparation.
- The microstructure of the clinker minerals was studied on a POLAM P-312 polarized optical microscope (Russia).

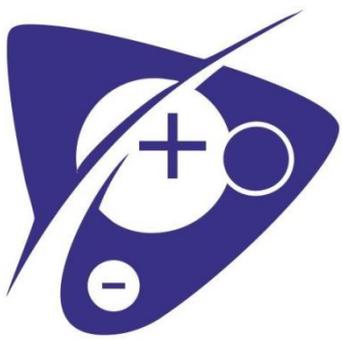


XRD patterns of cement clinker

of A-1 composition
obtained by low-
temperature plasma at
different exposure time:

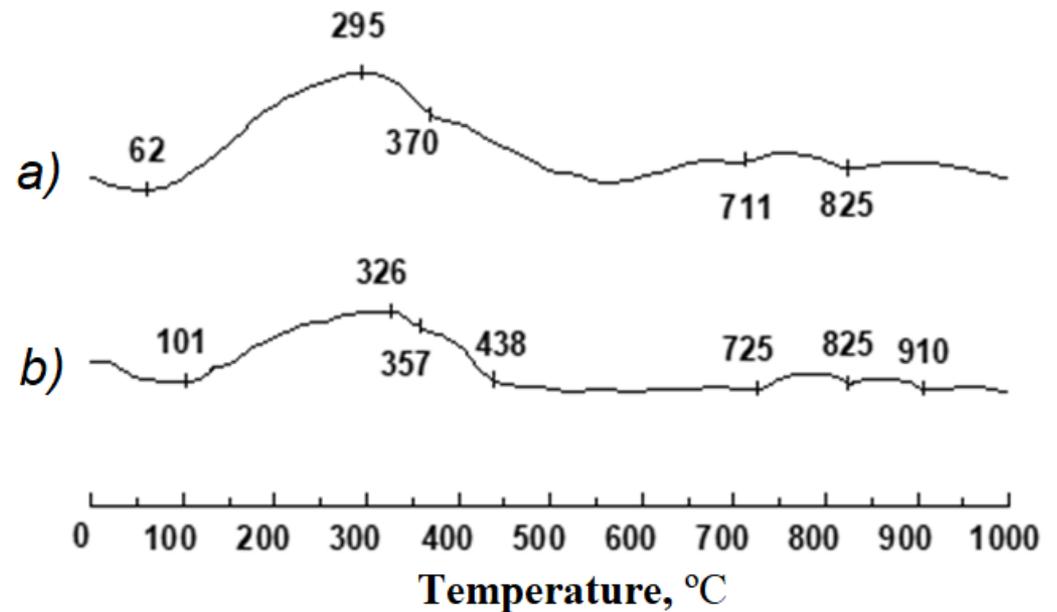
- *a* – 75 s,
- *b* – 90 s,
- *c* – 120 s.

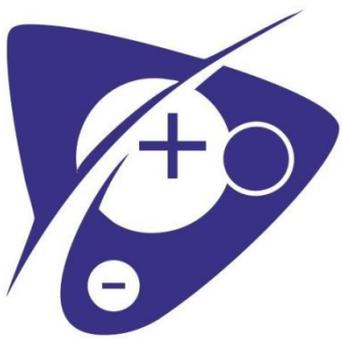




DTA curves of cement clinker

obtained by low-temperature plasma at 90 s exposure time from: *a* – A-2 composition with 0.9 saturation ratio, *b* – A-1 with composition with 1.03 saturation ratio.

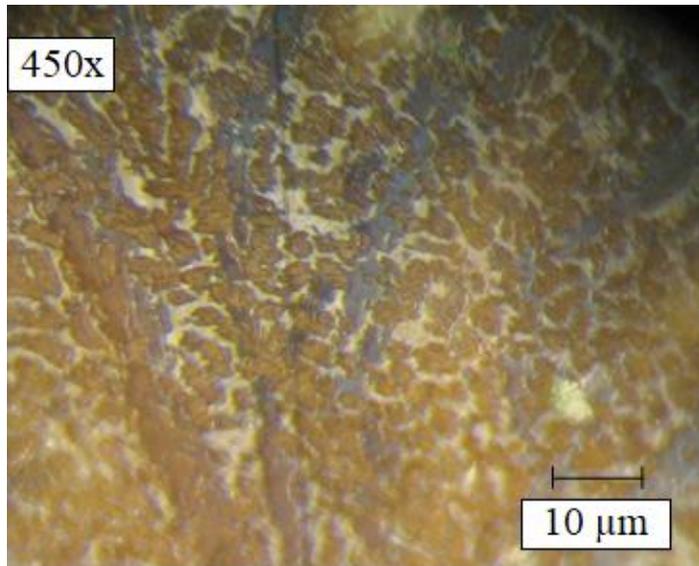




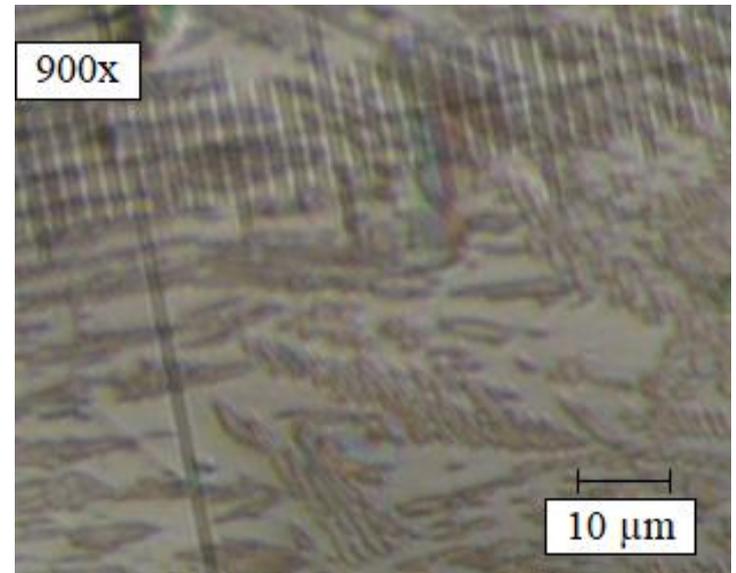
POM images of LTP-treated cement clinker

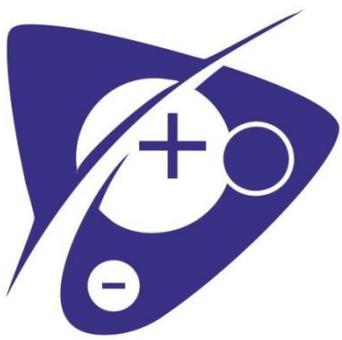
- produced from:

a – A-1 mix composition



b – B-1 mix composition.





Conclusions

- The process conditions of the low-temperature plasma (LTP) treatment included 3000–3500 °C temperature range, 90 and 120 s exposure time for using the conventional and man-made raw materials, respectively.
- The low-temperature plasma applied for the cement clinker synthesis, allowed us to produce the material containing the higher content of the alite metastable phase.
- In the non-equilibrium LTP conditions, the metastable clinker minerals were synthesized with the finer microstructure representing belite grains (2–26 μm) having a round or dendritic shape and alite grains (0.5–11) \times (5–36) μm either of acicular or lamellar shape.
- The LTP synthesis of the cement clinker allows using non-standard carbonate and silica-alumina raw materials along with the traditional. This provides recycling of man-made wastes, solves the ecological problem and expands the raw materials base of the cement industry.