

Analysis of Concrete

Concrete is an inhomogeneous building material. Its main components are:

- Aggregates with different size, < 1mm up to more than 16 mm
- Cement
- Air pores

A typical mass ratio cement/aggregates for concrete (B25) is in the order of 1/7.

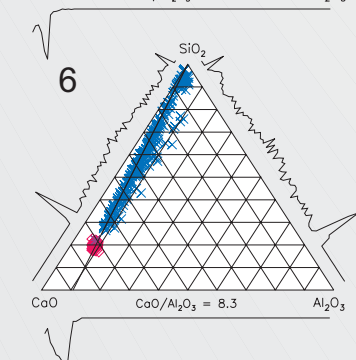
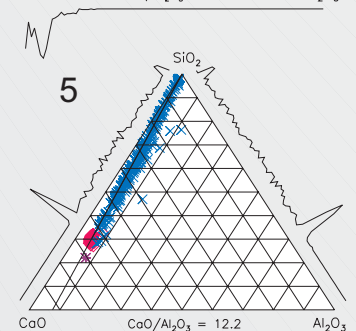
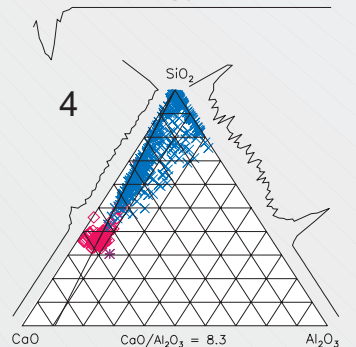
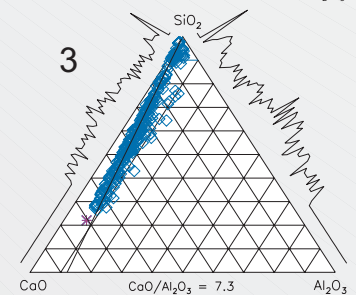
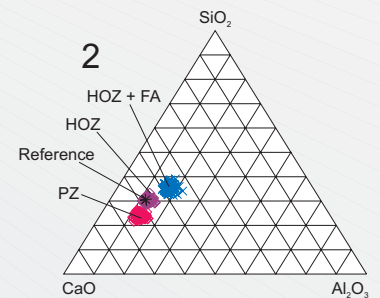
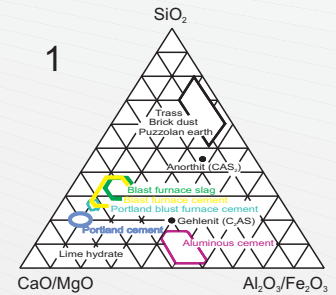
The main classes of aggregates are:

- silica, main component SiO_2
- dolomite, main components Ca/MgCO_3
- calcite, main component CaCO_3

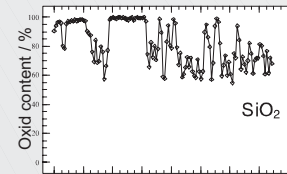
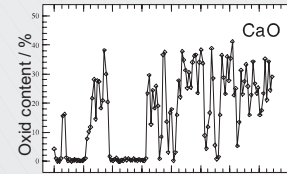
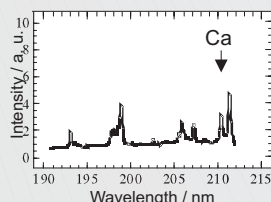
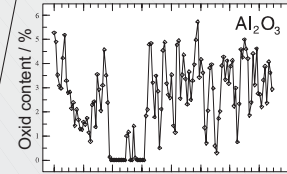
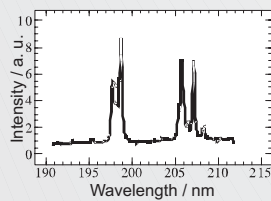
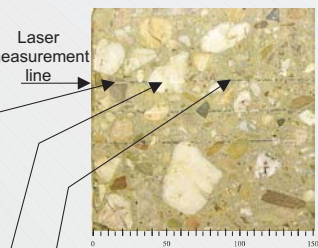
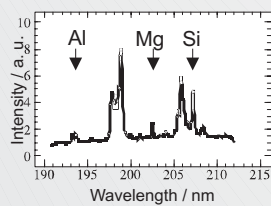
Typical composition of cements are shown in the table.

Chemical composition of some cements in % weight

Component	PZ	EPZ	HOZ	TrZ	ÖZ	TEZ	FA
CaO	61 - 69	52 - 66	43 - 60	43 - 58	53 - 58	23 - 41	3 - 6
SiO_2	18 - 24	19 - 26	23 - 32	25 - 28	19 - 21	1 - 7	44 - 50
$\text{Al}_2\text{O}_3 + \text{TiO}_2$	4 - 8	4 - 10	6 - 14	6 - 9	5 - 7	51 - 69	25 - 29
Fe_2O_3 (FeO)	1 - 4	1 - 4	0.5 - 3	2.5 - 3.5	3 - 6	1.5 - 0.5	7 - 14
Mn_2O_3 (MnO)	0 - 0.5	0 - 1	0.1 - 2.5	0.1 - 0.3	0.1 - 0.2	0 - 0.1	-
MgO	0.5 - 4	0.5 - 5	1 - 9.5	1 - 3	1.5 - 2.5	0.3 - 1.5	1 - 3
SO_3	2 - 3.5	2 - 4	1 - 4.5	2 - 3	2.5 - 3.5	0.1 - 0.7	0.5 - 5



Silica aggregate with Al



To analyze concrete the element content of Calcium, Silicon and Aluminum was measured. To consider the large inhomogeneity of concrete a representative number of linescan measurements was taken, each with 127 single reading points (right). The corresponding oxide content was calculated using stoichiometry. Those values are then included in a Rankin diagram. The measured values in the Rankin diagram form a typical distribution used for the identification of the concrete.

The results (1 - 6 in the right column) were obtained on different cement and concrete specimens. The large scattering of the values (see 3 - 6) is caused by the material and not by the LIBS method. Clockwise along the sides of the triangles, the density function for the elements are shown. They can be used as an additional criterion for the characterization of the concrete. The values obtained by the reference specimens are indicated by *.

- 1 Rankin Diagram for various cement types (from literature)
- 2 Results of three different cement specimens (each 127 measurements): Portland cement (PZ), furnace blast slag cement (HOZ) and furnace blast slag cement containing 30 % fly ash (HOZ+FA)
- 3 Results from a cutted concrete surface. The distribution of the points along a line is caused by the ratio cement/aggregate in the evaporated material.
- 4 Comparison of LIBS results from a casted surface (red) and a cutted surface (blue) of a concrete specimen; aggregates contain additional Al_2O_3
- 5 like 3, but silica aggregates and Furnace blast slag cement
- 6 like 4, but Portland cement