Development of alkaline activation materials from metallurgical slags: ferrosilicon and steel slags

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INTRODUCTION

ENVIRONMENTAL CONTEXT

1 Ton of Portland Cement → 0.5 Ton of CO_2

ALTERNATIVE

GEOPOLYMERS OR ALKALI ACTIVATED MATERIALS

20-50 % CO_2 emissions reduction
No high temperatures in manufacturing

Good thermal and mechanical properties
High chemical attack resistance

PRECURSOR + ACTIVATOR = GEOPOLYMER

Solid waste. Source of aluminosilicate

ALKALI SOLUTION
NaOH 6 M + Na_2SiO_3 solution (35/65 weight ratio)

Sodium or calcium aluminosilicate hydrate chains

RAW MATERIALS

1. Ferrosilicon slag (FS)

2014-2018 average global ferrosilicon production:

6.91 Million of tons

Slag theoretically available per year:

280000 Tons

2. Steel slag (SS)

Addition in percentages from 0 % up to 50 %
OBJECTIVE:
Improvement of mechanical properties

SAMPLES MANUFACTURE

Ferrosilicon slag + steel slag + alkali solution ($NaOH + Na_2SiO_3$)

Planetary mixer homogenization (120 s)

Pouring into moulds (10 x 10 x 60 mm)

60 strokes on Proeti punching table

Samples demoulded at 24 h

Curing at room temperature until the age of test

RESULTS AND DISCUSSION

MIXTURES DESIGN

1. Raw materials composition

Ferrosilicon slag (FS)		Steel slag (SS)	
SiO_2	38.91 %	CaO	29.45 %
CaO	28.06 %	Fe_2O_3	28.61 %
Al_2O_3	11.94 %	SiO_2	18.59 %
MnO	9.53 %	Al_2O_3	9.44 %
MgO	4.12 %	MgO	4.56 %
BaO	2.87 %	MnO	4.18 %
SO_3	1.70 %	TiO_2	0.95 %
K_2O	1.22 %	LOI	1.39 %
Other	1.65 %	Other	2.83 %

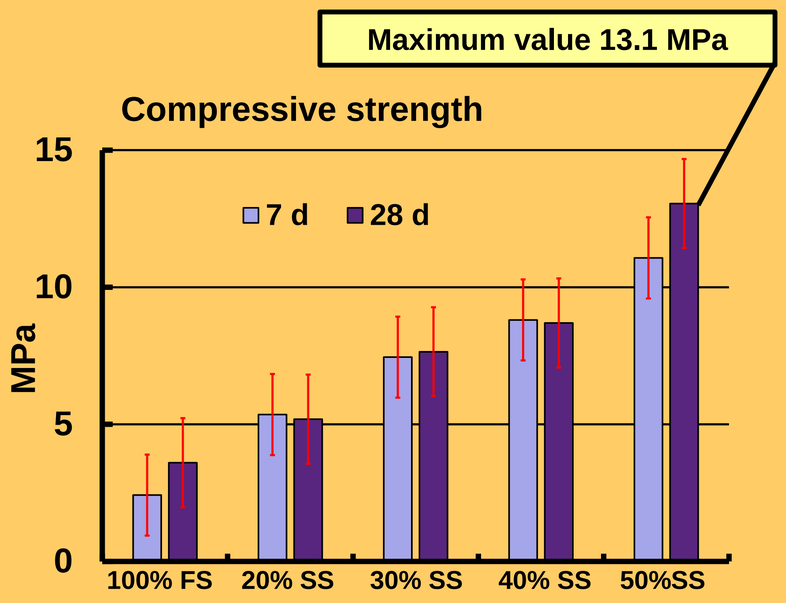
2. Mixtures composition

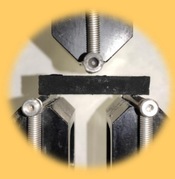
Sample	FS	SS	*NaOH 6 M + Na_2SiO_3 Solution (35/65)*
100% FS	300 g	0 g	120 g
20% SFE	240 g	60 g	120 g
30% SFE	210 g	90 g	120 g
40% SFE	180 g	120 g	120 g
50% SFE	150 g	150 g	120 g

(Ratio water/binder was adjusted to maintain workability)

COMPRESSIVE STRENGTH

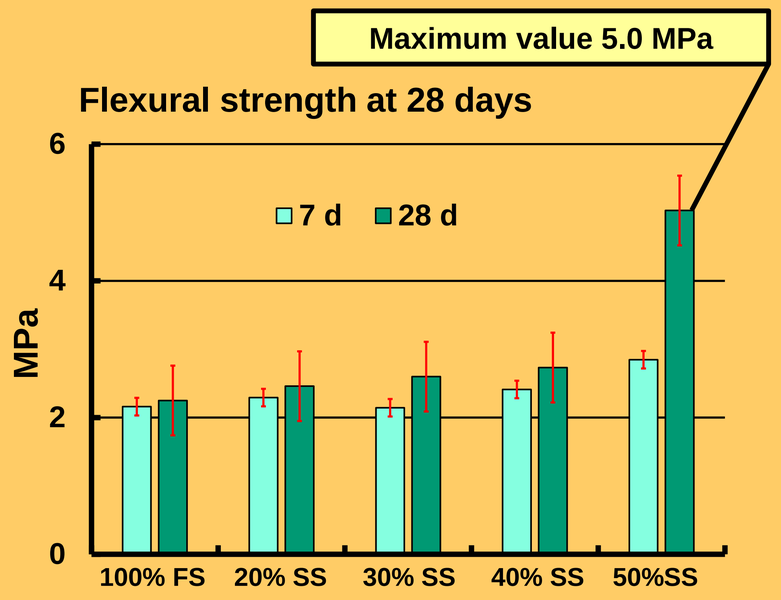
Steel slag addition generally improves the compressive strength in percentages up to 50 %





FLEXURAL STRENGTH

Ferrosilicon slag geopolymers seems to improve their flexural strength with steel slag addition.



CONCLUSSIONS

Experimental investigation revealed that the addition of steel slag in the ferrosilicon based alkali activated cements improved their reactivity reaching a compressive strength of 13.1 MPa, with the addition of 50 wt % of steel slag. The improvement of mechanical strength can be attributed to the better reaction of geopolymerization and the better structure in the geopolymeric gel. Therefore, the use of these new and more sustainable conglomerates may reduce CO_2 emissions and relieve one of the causes of global warming, as well as making good use of metal slags which are considered industrial debris.

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