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Effect of Pozzolanic Additives on the Strength Development of High Performance Concrete

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Actuality

- When Portland cement clinker is produced there is a significant amount of CO_2 emitted from the calcination of the limestone. Cement production generates 222 kg of CO_2 in average on 1 ton of cement produced. In order to reduce the emission of CO_2, reduction of the cement amount in concrete production and usage of pozzolans is an advantage.
- It has been found that silica fume has a superior influence on the strength development of concrete but calcined clay increase its density and decrease size of dominating pores.

Actuality

- Materials that exhibit pozzolanic activity can decrease the hydration heat by means of cement substitution, which increases the heat generated during hydration due to the pozzolanic reaction.
- Pozzolans are known to increase the durability, lower the hydration heat, increase the resistance to sulphate attack and reduce the energy cost per cement unit.

The aim

- The aim of this research is to estimate the effect of pozzolanic substitutes and their combination on the temperature generated by the cement's hydration and on the final strength of high performance concrete.
- Consequently, the present study attempted to modify the properties – to diminish hydration heat with purpose to decrease drying shrinkage and increase durability, to obtain ‘greener’ concrete by using lower amount of Portland cement and therefore CO_2 emission, to get similar or higher compression strength of blended concrete which contained silica fume and calcined clay.

Raw materials

Silica fume ("Elkem Microsilica® Grade 971-U")
300 kg/m^3
18-20 m^2/g

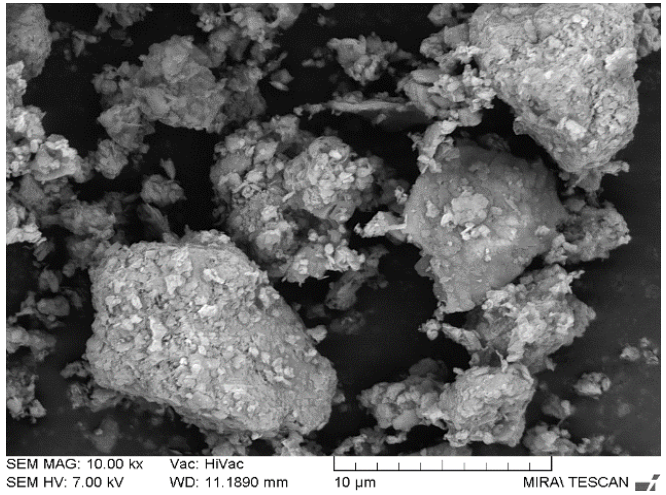
Calcined illite clay (brick factory "Lode")
21.4 m^2/g

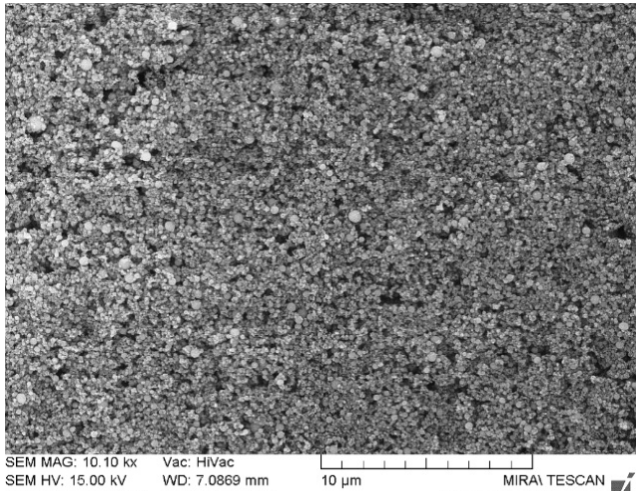
Portland cement ("Kunda®" CEM I 42,5 N)

Sand
0 to 1.0 mm, humidity less than 0.2%, bulk density 1425 kg/m^3

Superplasticizer admixtures ("Sikament® 56")

H_2O (by consistence)



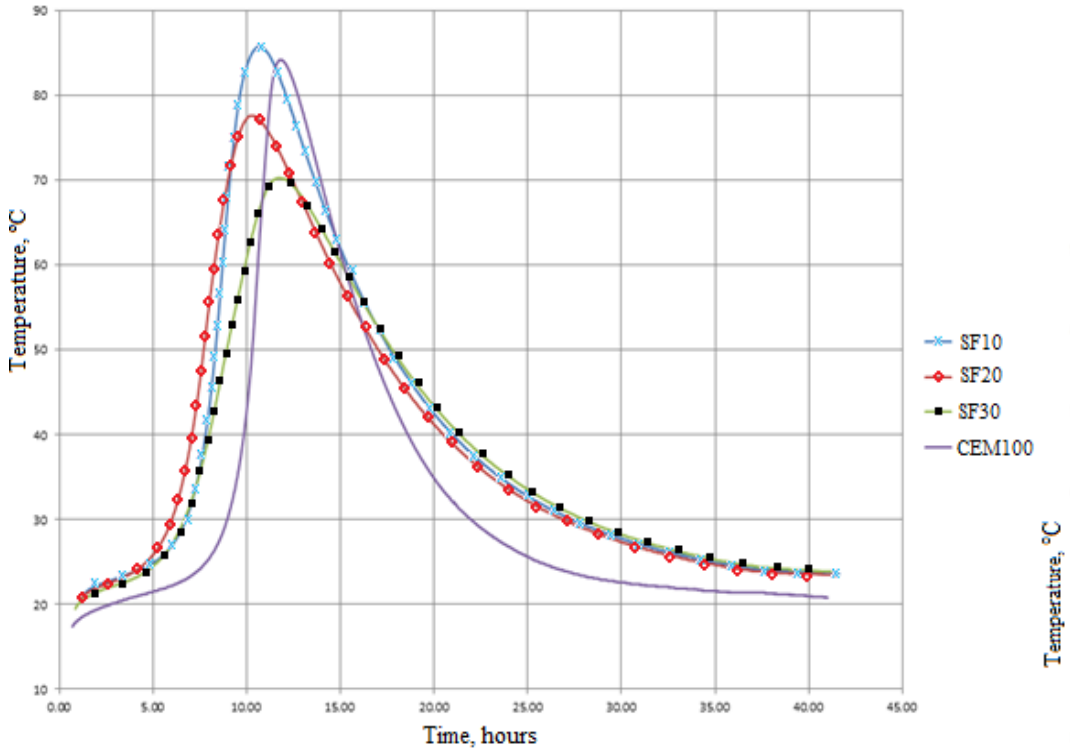


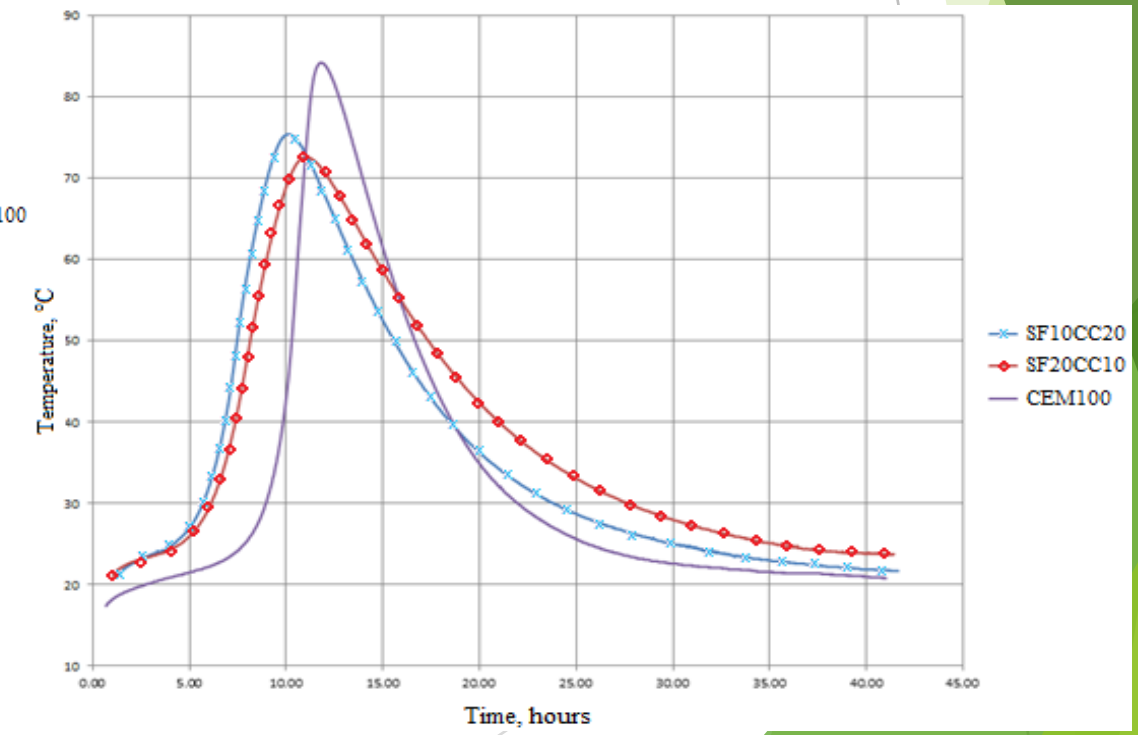
Compositions

	Compositions of Cement pastes, %				
	Cement paste			SP	W/C
	CEM	SF	CC		
CEM100	100	0	0	0.5	0.21
SF10	90	10	0	0.5	0.27
SF20	80	20	0	0.5	0.29
SF30	70	30	0	0.5	0.34
SF10CC20	70	10	20	0.5	0.25
SF20CC10	70	20	10	0.5	0.31

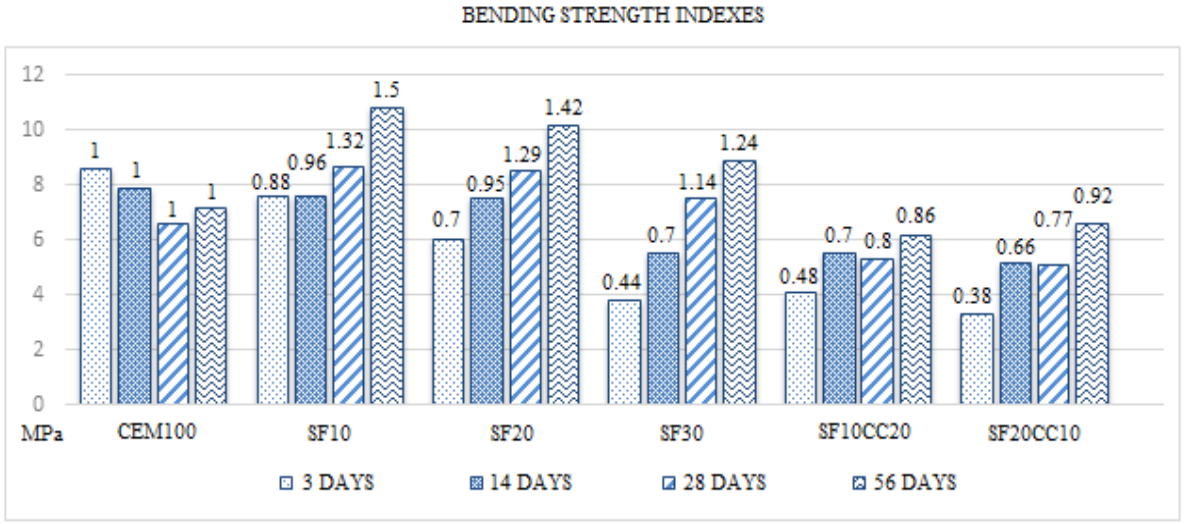
	Compositions of Cement mortars, %					
	Cement paste			SP	Sand	W/C
	CEM	SF	CC			
CEM100	100	0	0	0.5	100	0.26
SF10	90	10	0	0.5	100	0.27
SF20	80	20	0	0.5	100	0.29
SF30	70	30	0	0.5	100	0.36
SF10CC20	70	10	20	0.5	100	0.32
SF20CC10	70	20	10	0.5	100	0.38

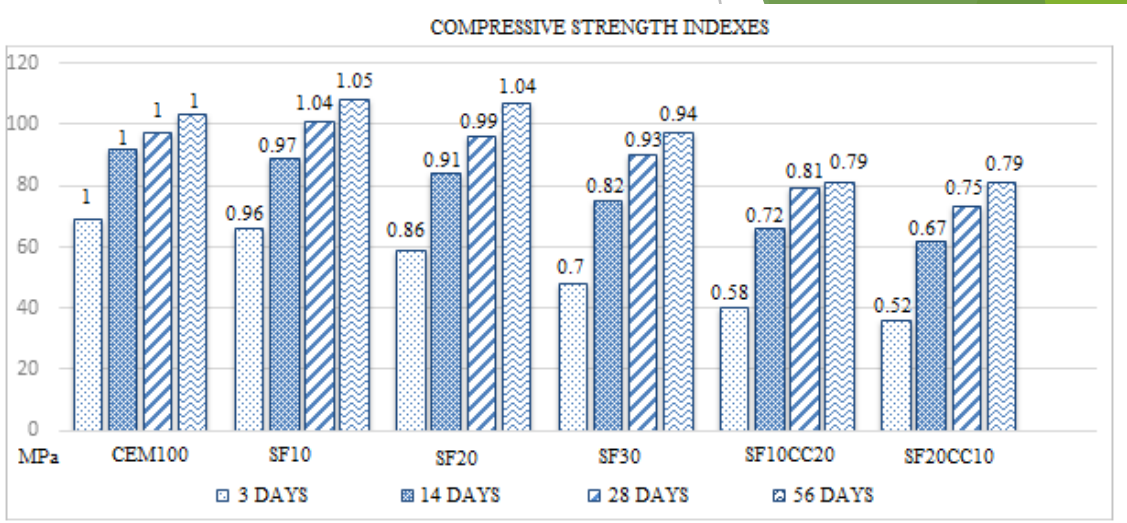
Curves of the hydration temperature for cement paste specimens





Results





- Pozzolans (in this case SF) leads to incensement of mechanical properties (especially bending strength) for specimens in prolonged curing period; however, more successful are compositions where no more than 20% of cement are replaced by SF. Ternary pozzolan systems do not prove to be efficient in this case. By replacement of PC by 30%, compression strength diminishes by 20% in comparison with CEM100.

Conclusions

- Reduction of hydration temperature has a positive influence on the concrete hardening process and decreases the risk of having micro cracks in the concrete at its early age. All compositions reached maximum temperature in 11-13 hour interval.
- Analyzing the compressive strength results obtained for SF, CEM and SF-CC combinations, it can be concluded that the highest early compressive strength for 3-day-old concrete is for the reference composition of CEM100. Namely, more cement in the composition leads to a higher early strength for these compositions (both bending and compressive strength).
- While testing the 56 days-old samples, the reference composition CEM100 was outperformed by SF10 and SF20.
- Ternary systems (SF10CC20 and SF20CC10) show the lowest results for all ages (3, 14, 28 and 56 days old concrete) with regards to both bending and compressive strength.

Acknowledgements

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Thank You for attention!