DEVELOPING NON-EXPANSIVE CALCIUM SULFOALUMINATE CEMENTS FOR ORDINARY CONCRETE APPLICATIONS

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CSA as an OPC Alternative

- Calcium sulfoaluminate cements (and related products) are used for repair and specialty applications.

- CSA cement can easily replace portland cement in concrete if the following are approximately equal:
  - Setting and mechanical property development
  - Dimensional stability
  - Durability
  - Cost

Designed Phase Assemblages

Target Compositions

	*#1 (HS)**	*#2 (MS)*	*#3 (LS)*
$C_4A_3\hat{S}$	60	40	20
C_2S	20	40	60
C_4AF	10	10	10
$C\hat{S}$	10	10	10

Made in a laboratory muffle furnace with reagent grade materials

Materials proportioned using Bogue-type equations

2-cycle heating with intermediate grinding; max. temperature = 1250°C

*HS, MS, LS = High, Medium and Low Sulfoaluminate content

Actual Phase Assemblages

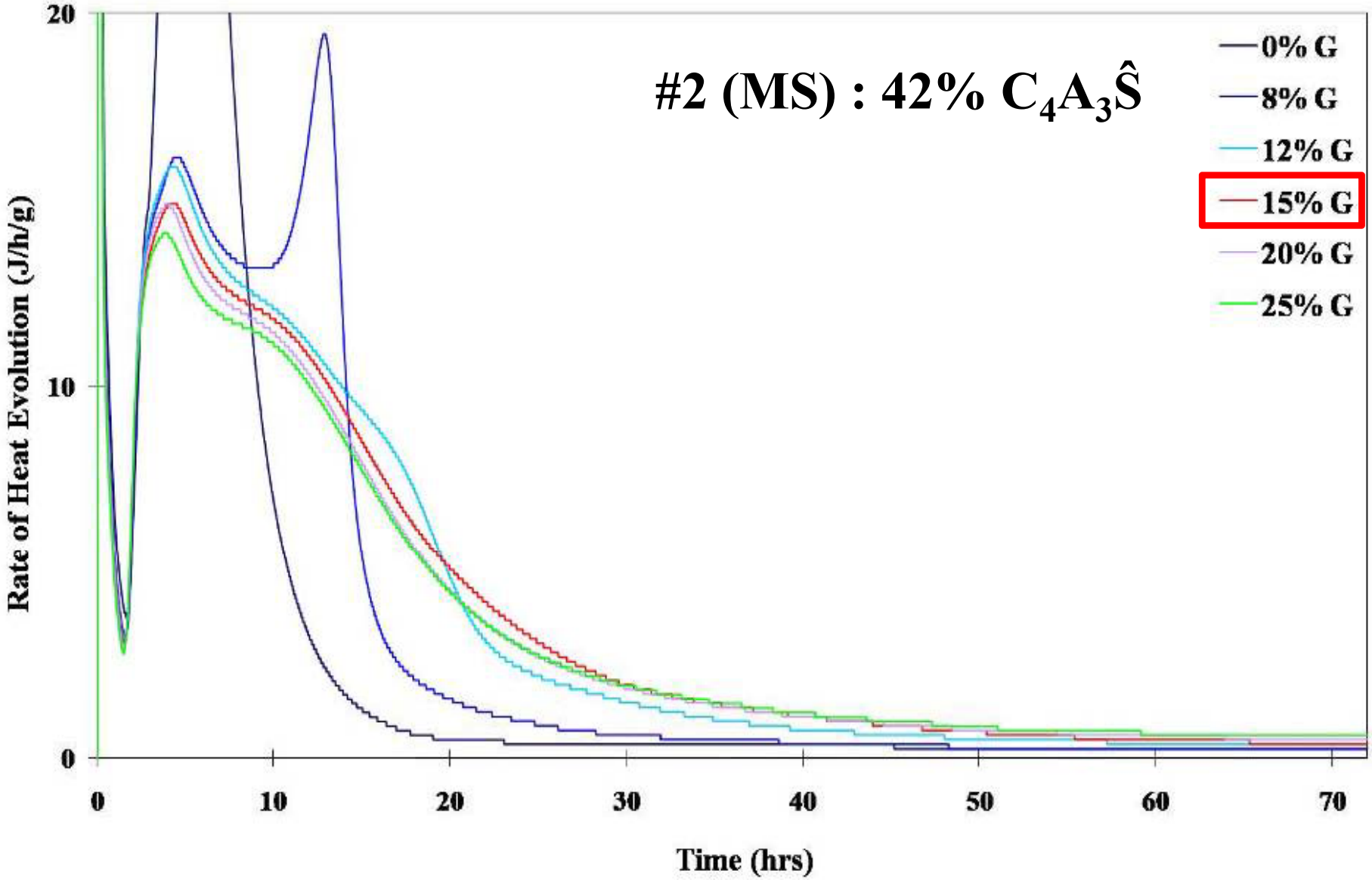
- Phase composition determined by Rietveld quantitative x-ray diffraction

	#1 (HS)		*#2 (MS)*		*#3 (LS)*	
	Target	Actual	Target	Actual	Target	Actual
$C_4A_3\hat{S}$	60	65	40	42	20	15
C_2S	20	22	40	45	60	71
C_4AF	10	3	10	6	10	7
$C\hat{S}$	10	9	10	7	10	7
$C\hat{S}H_2^*$	23	25	19	15	10	8

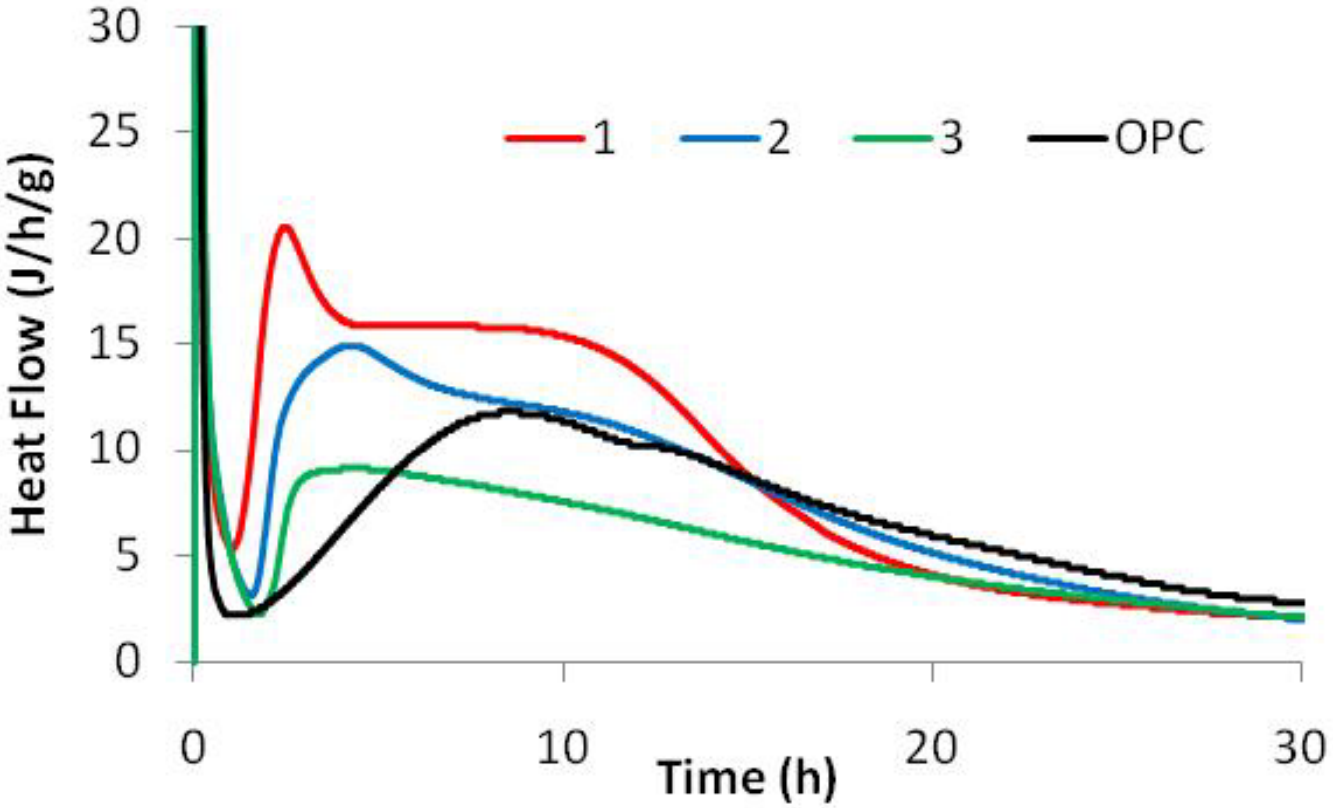
*$C\hat{S}H_2$ added after clinkering

- Target is stoichiometric based on complete reaction
- Actual is based on results of isothermal calorimetry testing with different amounts of gypsum

Proportioning Gypsum

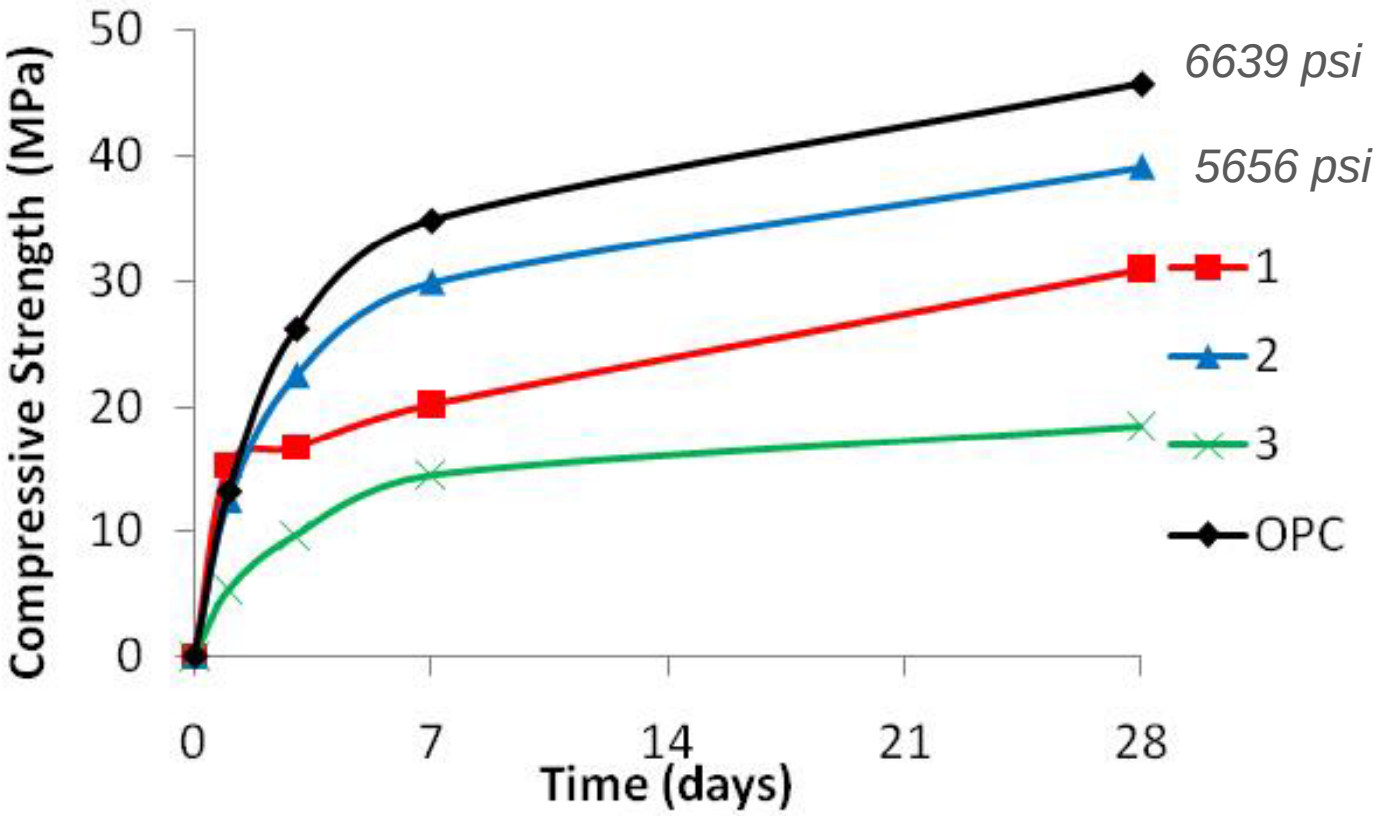


Hydration Rate



Isothermal calorimetry of pastes with optimum gypsum added
w/c=0.45
23°C

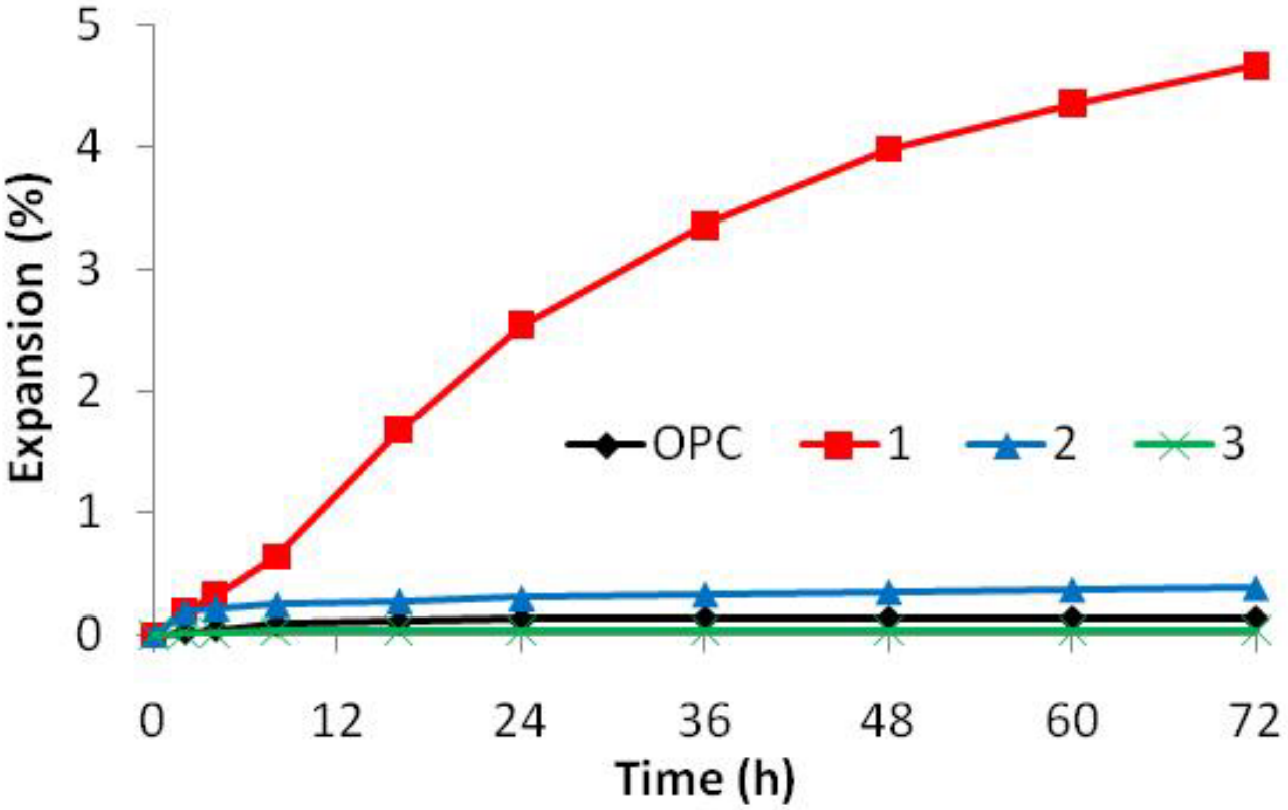
Compressive Strength

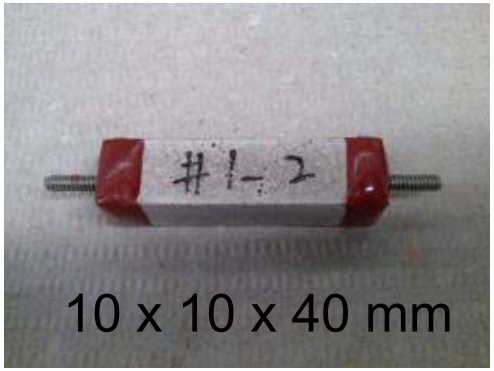


Compression of mortar cubes (50mm x 50mm)
ASTM C 109

Optimum gypsum added to clinkers

Expansion in Water





Paste prisms (w/c=0.45)
Demolded at 24 hours and placed in water at 23°C

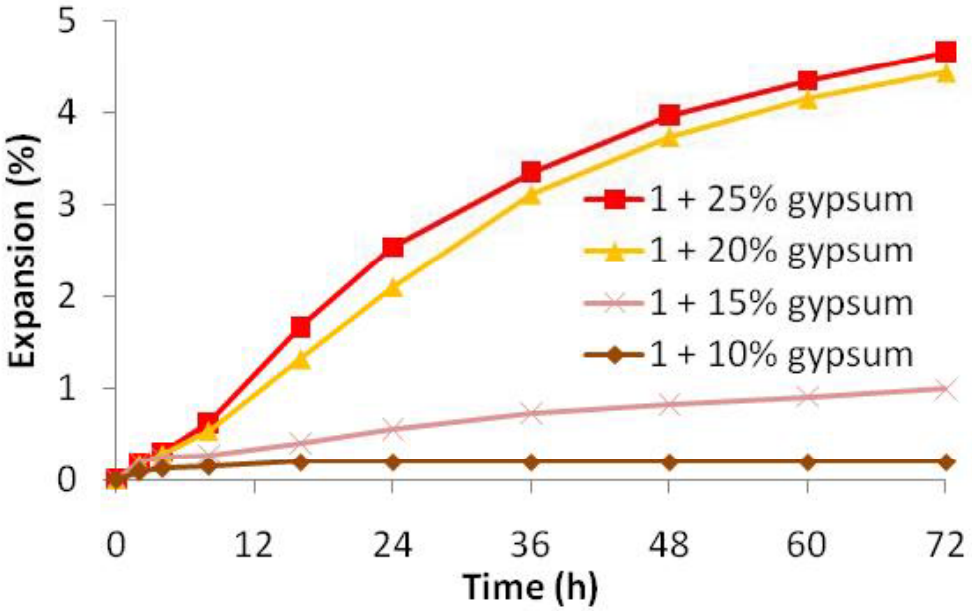
Optimum gypsum added to clinkers

Second Phase of Study

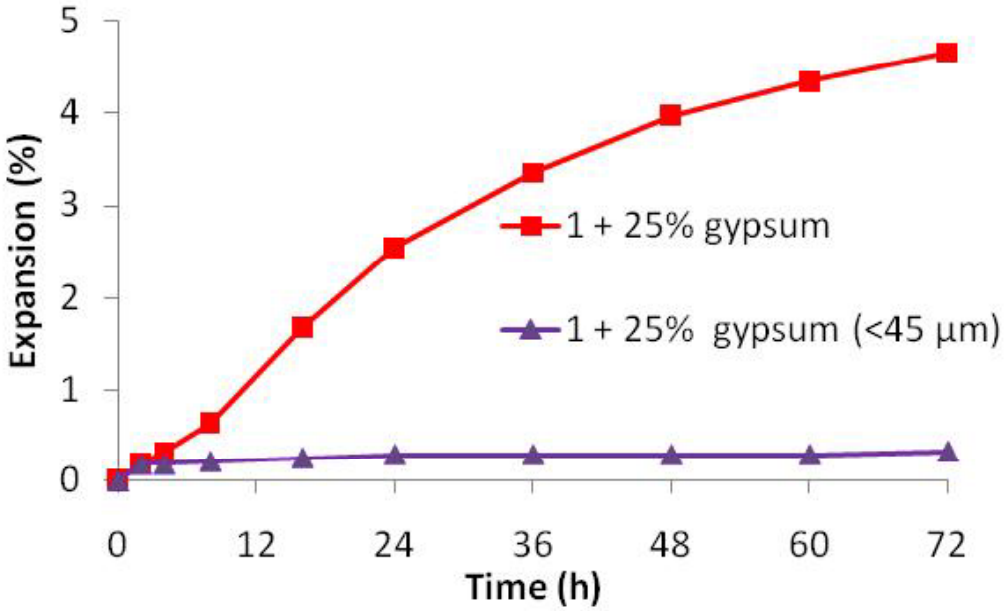
- CSA with high $C_4A_3\hat{S}$ is highly reactive, with good potential for high strength. Can detrimental expansion be avoided?

- The cost of raw materials for CSA is high, can this be lowered by using waste materials without compromising properties?

Controlling Expansion

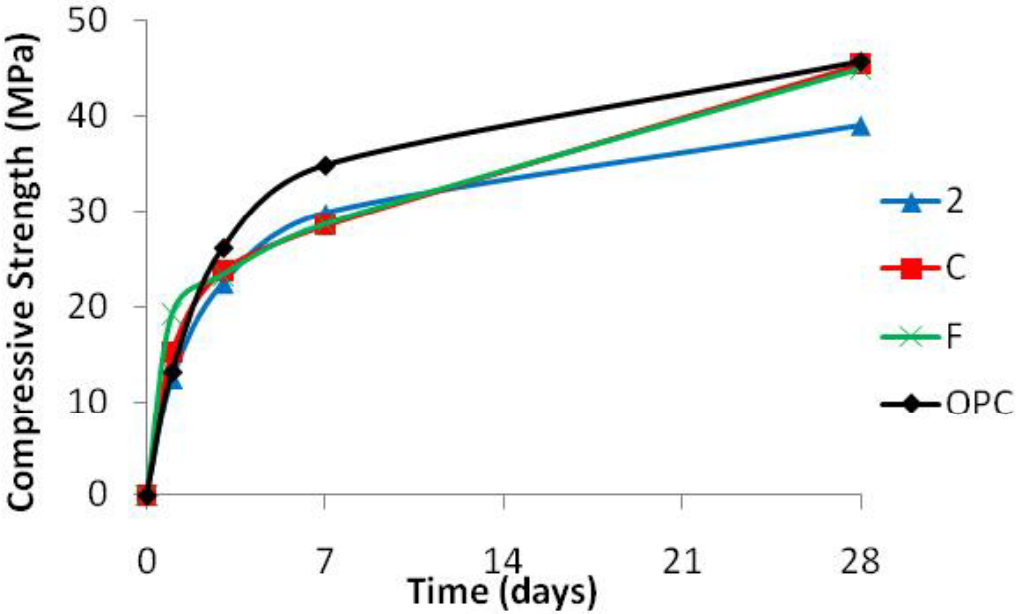


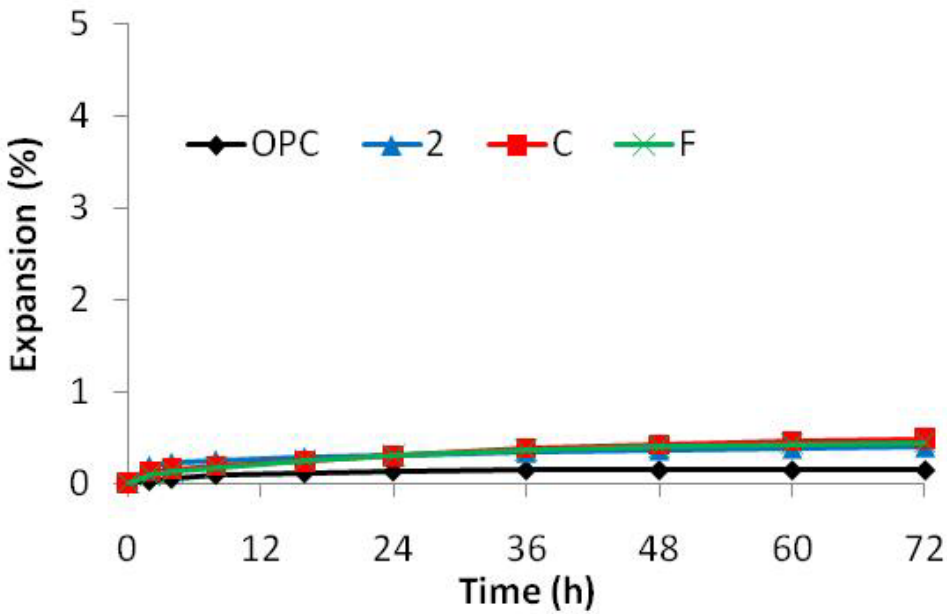
Lower gypsum addition reduces expansion



Reducing particle size (through sieving) reduces expansion

Clinkers from natural and waste raw materials





•Clinkers made from limestone, bauxite, fly ash (C), fluidized bed ash (F), and flue gas desulfurization sludge.

•Alkalis in the raw materials accelerated the hydration reactions and expansion, so 1% citric acid was used as a retarder.

Conclusions

- CSA phases can be proportioned to achieve performance similar to OPC in terms of:
  - Reaction rate/setting time
  - Compressive strength development
  - Expansion in water
- CSA can be made from a combination of natural and waste materials to lower cost without sacrificing performance
- Long term durability was not examined in this study, but must be performed before use

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