Optimising the strength of concrete without using cement

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Optimising the Strength of Concrete Without using Cement

Professor Pete Claisse, Seema Karami
Coventry University UK

- Materials
- Strength Tests
- Other tests
- Site Demonstrations

Materials

ROSA = Run of Station Ash (Coal fired power plant) BPD = By-pass dust (Cement works)

PG = Plasterboard (wall board) gypsum BOS = Basic Oxygen Slag (Steel works)

RG = Red Gypsum (Titanium dioxide pigment plant)

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Laboratory Testing

1- Mix, 5 min

2- Samples

3- Crush Samples,
3, 7, and 28 days

Trial Mixes

Step No.1:

Optimization Of Binary Combinations

BOS + { RG, PG, ROSA, BPD } , ROSA + { RG, PG, BPD } , BPD + { RG, PG }

= 50 MIXES (300 samples) 0.3 liquid/solids in every mix

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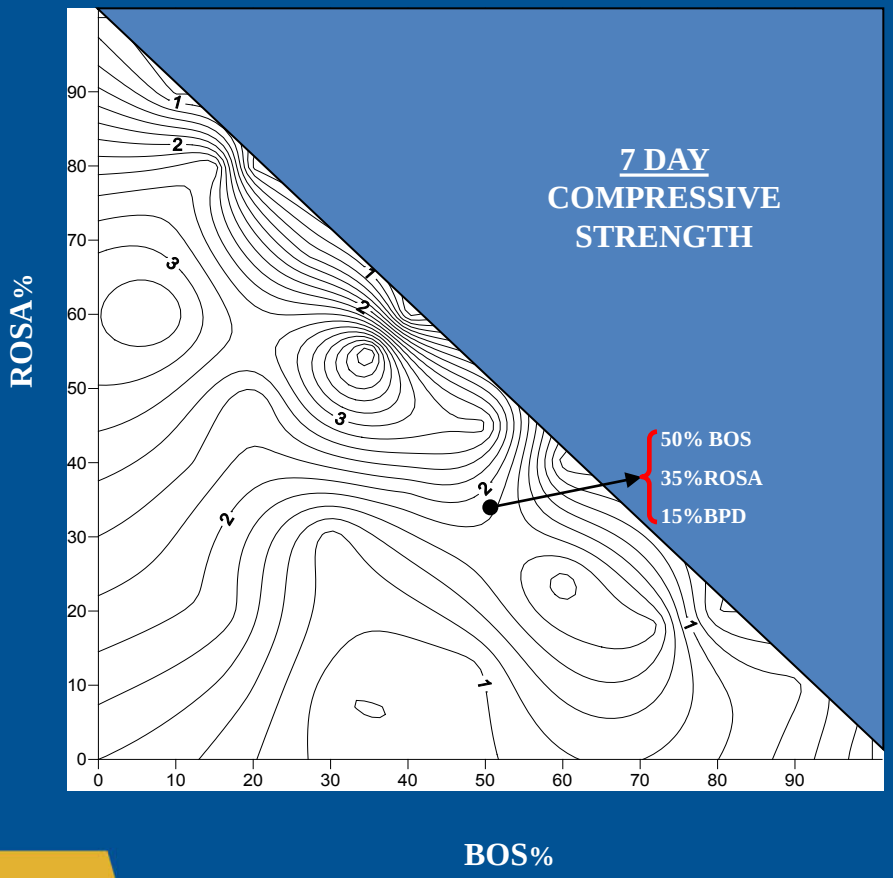
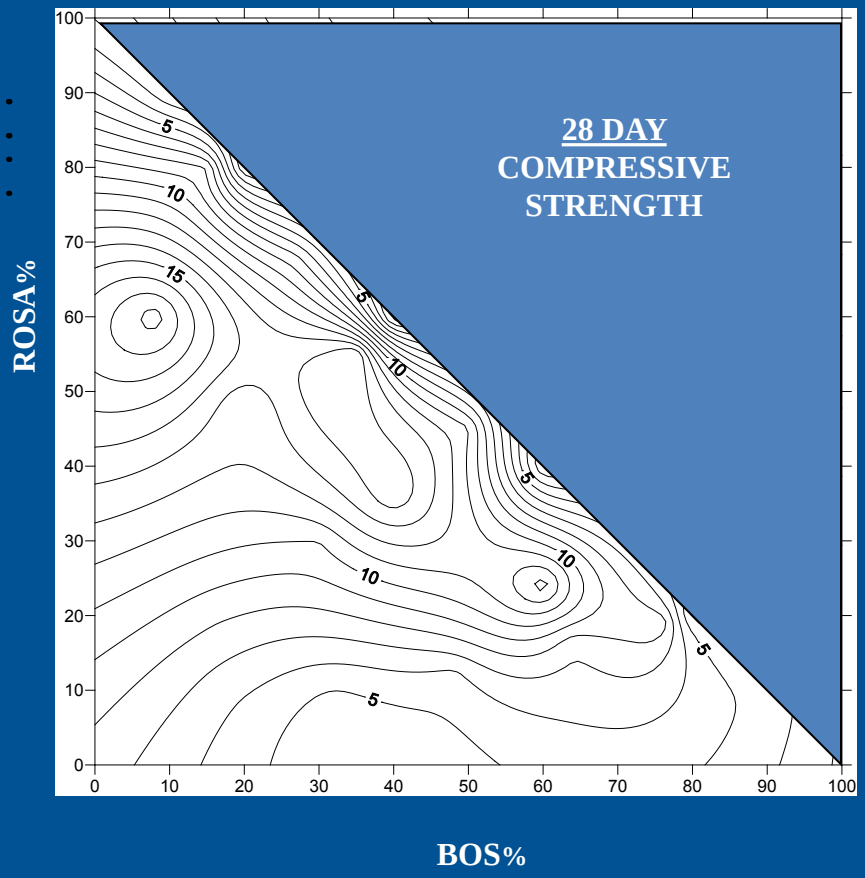
BOS + ROSA +BPD Compressive strength MPa





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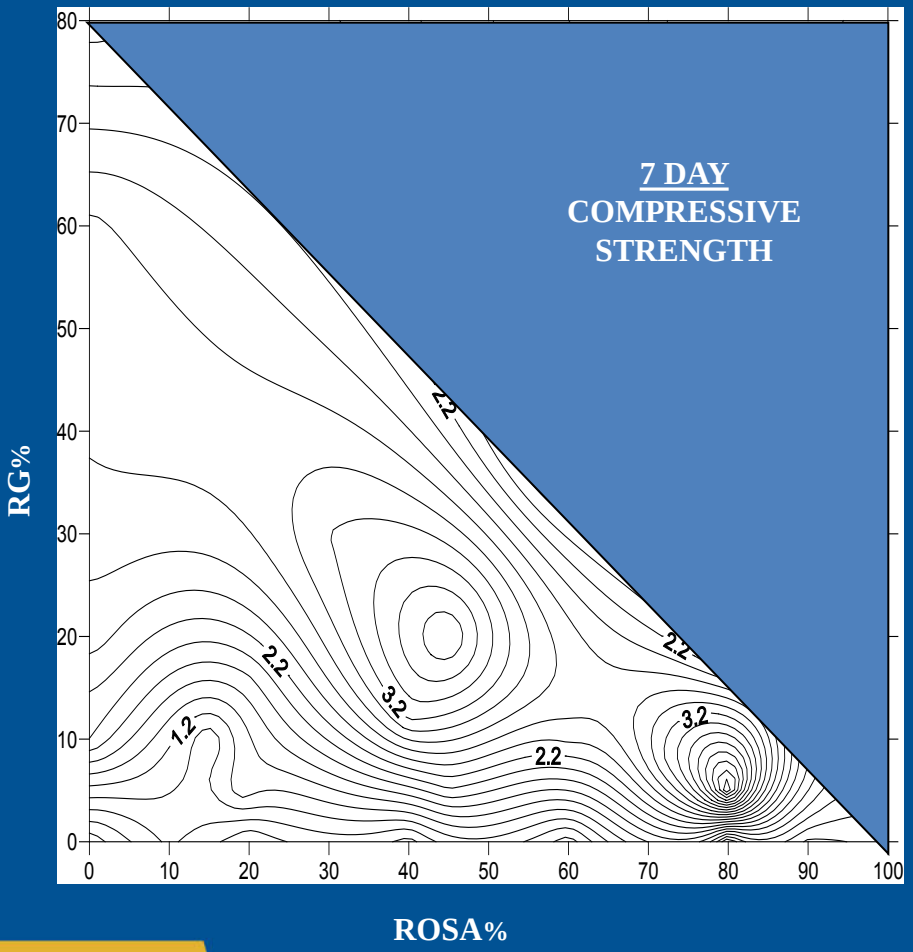
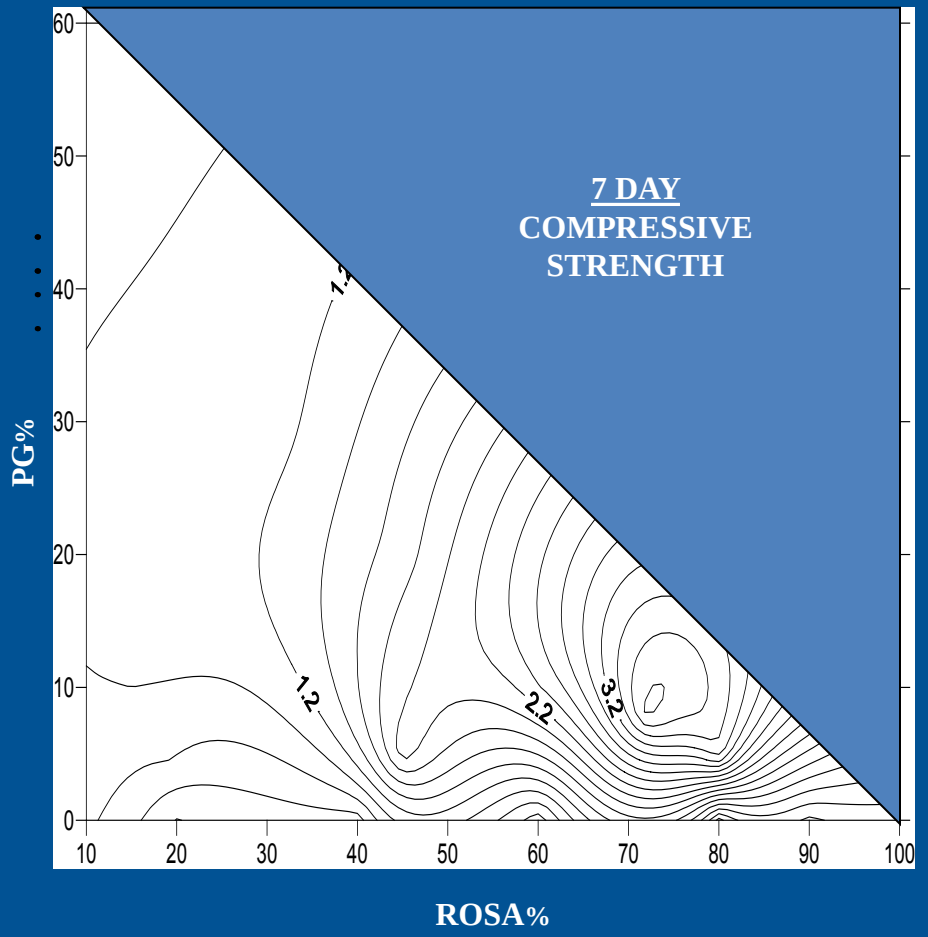
BOS + ROSA +RG



Compressive strength MPa



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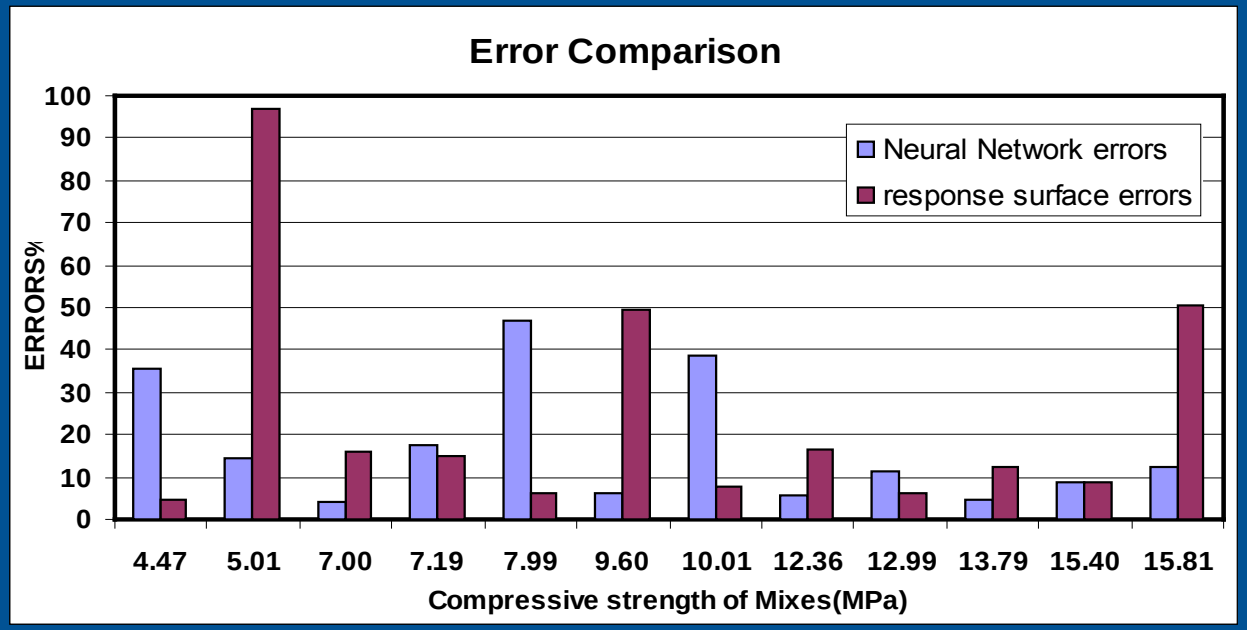
Mathematical Modelling Comparisons

BOS	0.32	0.51	0	0.64	0	0.8	0	0.12	0	0.5	0.35	0
BPD	0.6	0.34	0.05	0.2	0.1	0.08	0.15	0.48	0.18	0	0	0.1
ROSA	0.08	0	0.855	0.16	0.81	0	0.765	0.4	0.72	0.45	0.45	0.81
PG	0	0.15	0	0	0	0.12	0	0	0	0	0	0.09
RG	0	0	0.095	0	0.09	0	0.085	0	0.1	0.05	0.2	0
Comp. Strength Mpa.	4.47	5.01	7.00	7.19	7.99	9.60	10.01	12.36	12.99	13.79	15.40	15.81



The Optimised Mixture Designs

BOS%	ROSA%	RG%	PG%	W/C	7 Day Strength MPa	28 Day Strength MPa	Density Kg/m³
48	40	12		0.2	2.6	17.5	2024
40	50	10		0.23	2.7	18.2	1912
40	50		10	0.2	2.0	19.4	1904
30	60	10		0.73	2.5	18.9	1820
30	60		10	0.47	2.38	18.6	1823

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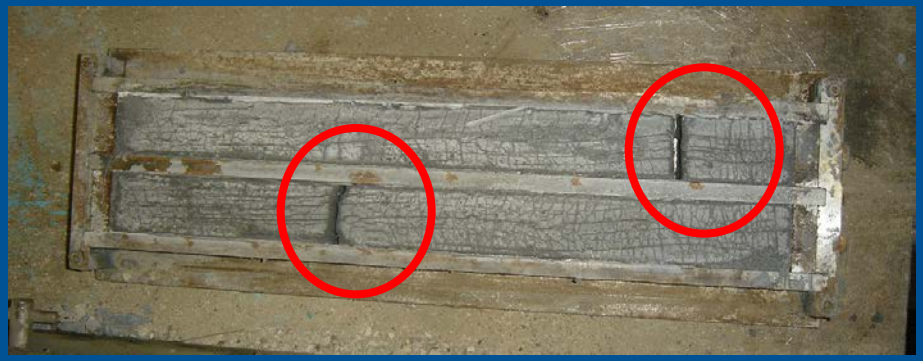
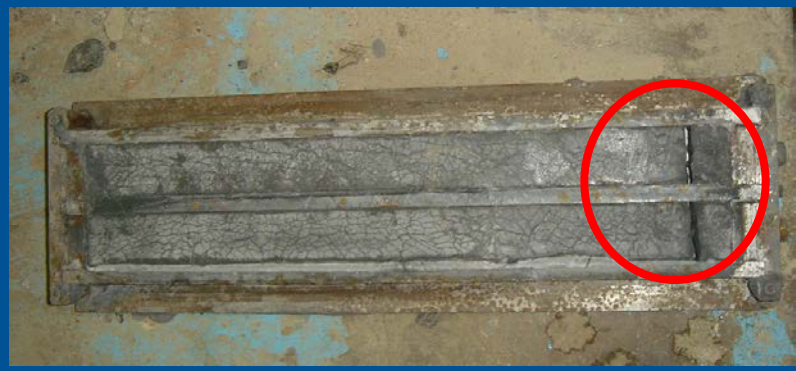
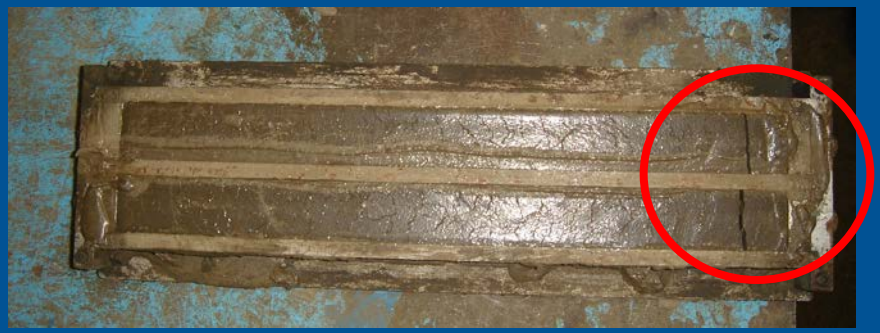
Sample Expansion





BOS+BPD+PG+30%L/S



BOS+ROSA+RG+27%L/S

BOS+ROSA+RG+25%L/S

Other tests carried out or in progress

Rheology – viscosity and yield point

Freeze-thaw

Permeability (picture below)

Diffusion (picture below)

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The mixture designs for the trials

Trial	Pour	Cementitious component	Strength MPa
1	Cell 1 top	Spent borax 100%	4.5
2	Cell 2 top	CKD 60%, Lagoon ash 40%	1.7
3	Cell 3 top	CKD 60%, Lagoon ash 40%	1.3
1	Cell 1 base	GGBS 90%,OPC 10%, Sodium sulphate	13
2	Cell 2 base	CKD 60%, PFA 40%, Sodium sulphate	6.9
3	Cell 3 base	OPC 5%, CKD, 70%, Lagoon ash 25%	6
4	Trench fill	BOS 60%, Red Gypsum 40%	1.8
5	Sub-base	BOS 80%, PB 15%, BPD 5%	10.8
6	Base course	BOS 80%, PB 15%, BPD 5%	30.55

Secondary materials in the mixes

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Advancing concrete knowledge

Placing Trial 4.

The “Coventry Blend”

- Basic oxygen slag from steel manufacture (80%)
- Waste plasterboard (15%)
- Kiln by-pass dust from cement manufacture.(5%)

100 Tonnes of this blend were made for trials 5 and 6

This blend is not recommended for partial replacement of cement – it is for use without cement

Trial 5
Car Park

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Advancing concrete knowledge

"Design and Construction Compatibility"

Trial 6 Haul Road – Soil Stabilisation

Trial 6
Semi-Dry
Paste/grout

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Advancing concrete knowledge

Concrete without Cement (Trials 5 and 6)

Concrete (trial 5)

Semi-dry paste/grout

(trial 6)

CONCLUSIONS 1

- Viable mixtures which contain little or no Portland cement can be made for a wide variety of applications.
- Site trials represent the best route to develop these mixtures for commercial use.
- Pre-blended mixtures are the best way to use powder which contains several mineral wastes.

Conclusions 2

- While it is possible to demonstrate the viability of cementitious mixtures which are sustainable there are many difficulties which may prevent their industrial use. These include:
  - Insurance problems
  - Lack of capital investment
  - Environmental concerns which may or may not have any scientific basis

Thank you

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www.claisse.info