Properties of Sustainable Concrete

Presentation to BuildEx

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Contents

- Strength
- Workability
- Durability:
  - scaling
  - sulphate
  - water ingress
  - carbonation
  - shrinkage

Contents (Continued)

- Cost
- Availability

Focus

Use of fly ash to replace a portion of the portland cement in a concrete mix

Other SCMs can also be used (slag, silica fume)

Nature of Our Fly Ash

Sourced from thermal power plants:
– Washington
– Alberta

World class in terms of quality

Low lime and low carbon

Good and predictable performance

How Much Fly Ash is Available/-Used Annually?

Alberta	2.7 M^T
Now used	≈ 15%
Rest is dumped in landfill	
Canada	5.0 M^T
Now used	≈ 8%

How Much Fly Ash is Available/-Used Annually? (Continued)

World	500 M^T
BC uses	160,000 M^T

Future Availability of Fly Ash

Reduce

- Reduce coal-fired production of power
- Use of variable coal sources at a thermal plant

Future Availability of Fly Ash (continued)

Increase

- Add beneficiation to existing power plants with present lower quality fly ash

Practical Replacements with Today's Construction

Piles, footings, rafts	40 – 50%
Walls, columns	30 – 40%
Slabs, suspended	20 – 25%
Topping	15 – 20%
Tilt-up	0 – 15%
Precast	0 – 30%

Note: varies with ambient temperature

How CSA Code Treats HVFA

IF> 35% FA:

- have to extend curing
- use 56 day acceptance
- reduce w/cm if there is a risk of carbonation

Use of FA encourage to mitigate ASR

Costs

Cement	$135.00/T
Fly ash cost	$ 75.00/T

So if use a typical 30 MPa Mix can save ≈ $9.00/$m^3$ with 50% replacement

Costs (Continued)

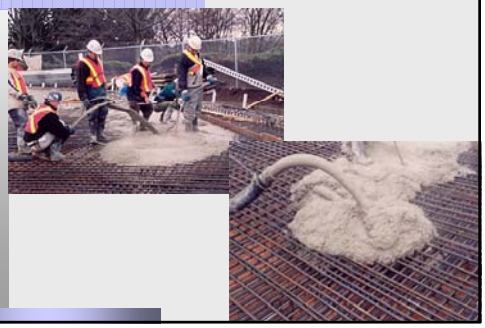
But may increase these construction costs:

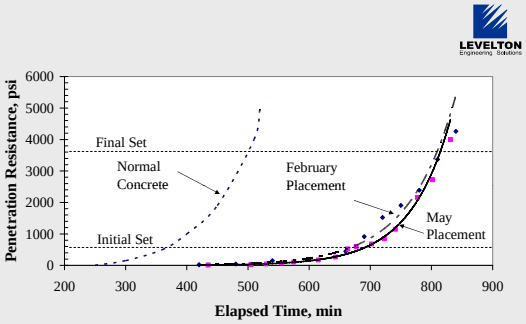
- time to finish flatwork
- time forms or shores are required to stay in place
- extended curing

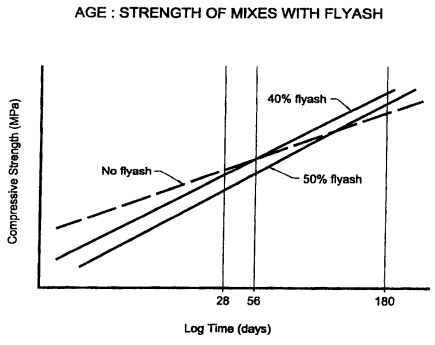
Workability

- Slower setting time
- Increased pumpability
- No bleed water
- User friendly

Little Mountain Reservoir







General Statement

With minor exceptions, the durability of concrete containing SCM replacements for cement will be equal to, or greater than the straight cement concrete.

Features of SCM Concrete re Durability

FA concrete has longer time to reach adequate durability.

Pore structure of paste more refined than OPC so aggressive agents have more difficulty penetrating. But also water movement internally is more restricted.

Sulphate Attack

Tests by Levelton and others show that:

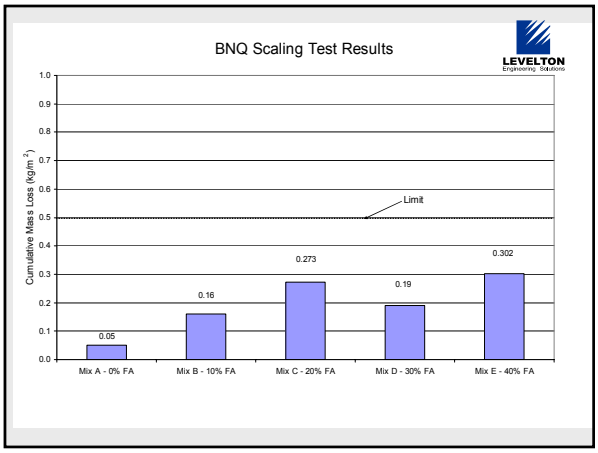
- Local cement + 25% +/- Fly Ash provides sulphate resistance ≥ Type HS.

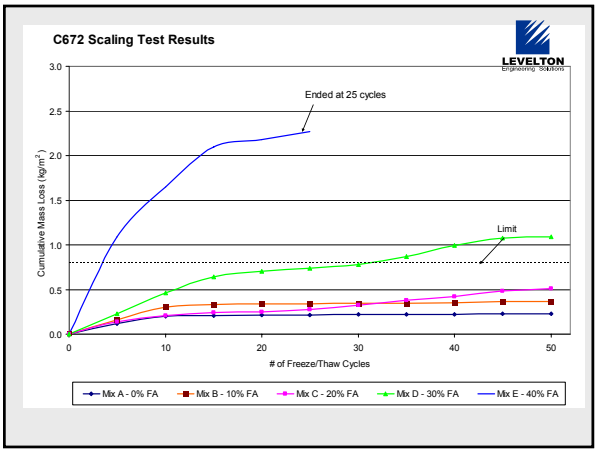
Shrinkage

Data generally shows that concrete with FA and SF has less shrinkage than straight cement concrete. However there are exceptions.

Scaling – Experience Elsewhere – Day, Calgary

"There are no test findings from this study that suggest that fly ash should not be used to produce durable flatwork installations. Visual examination of the curb and gutter after 20 years of exposure shows no significant difference between the performance of the control (plain concrete) mix and the fly ash mixes. Test results in the laboratory from both field-prepared concrete (from ready-mix trucks) and lab-prepared concrete indicate no significant differences between the plain concrete and the ash concretes – if anything, the ash concretes outperform the plain concrete controls."





Levelton re MSE Walls

Mix	Cement	330 kg/m³
	Fly Ash	30 kg/m³ (8%)
	Silica Fume	34 kg/m³ (9%)
After Scaling Test		
	Visual Class	1 → 2
	Mass loss	0.24 kg/m³

Abrasion Resistance (after Malhotra, Mehta)

Cementing Materials	Depth of Wear, mm @ 90 days
OPC	1.94
High Early	1.56
High Early with 50% fly ash	1.64
OPC with 50% fly ash	1.45

All mixes 40 to 45 MPa

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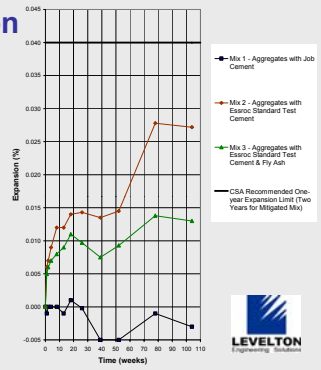
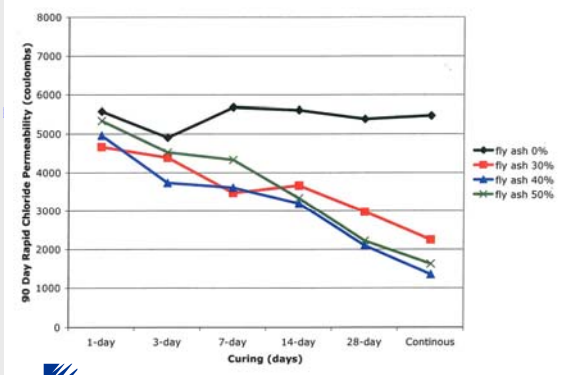
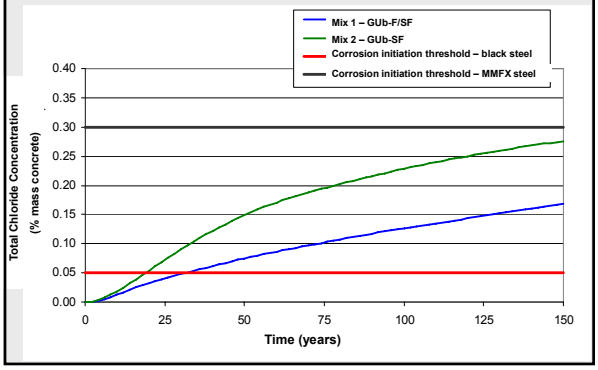
ASR Mitigation

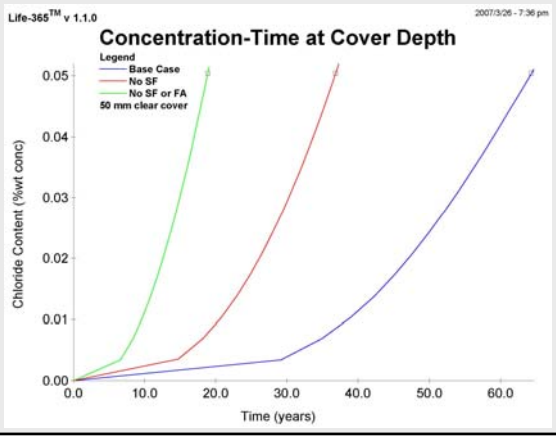




Graph courtesy of PCA

Modeling (concrete cover 60 mm)





Conclusion

Sustainable concrete can be produced by replacing a portion of the cement with fly ash.

The resulting concrete will have:

- Equal cost
- improved workability
- increased durability

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Thank You

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