"DEVELOPMENTS IN CONSTRUCTION MATERIALS"

SECBC Seminar

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Presented by:

Phil T. Seabrook, P. Eng.

Executive Vice President
Levelton Engineering Ltd.

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DISCUSS

- Concrete Specifications for Sustainability
- Service Life Predictions
- QA/QC
- New materials
- The meaning of life

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QUALITY MANAGEMENT

- **Integral part of D/B Contracts, eg. RTP Guideway**
- **Partially used in conventional Contracts**
  - **eg. Colwood Jetty**
  - **eg. YVR**

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QUALITY MANAGEMENT

(Continued)

Q.C. =

Contractor's responsibility to control the quality of the work to the Specification and in accordance with the pre-approved Q.C.P. and to document same.

Q.C. can save $.

Less chance error.

Identify items missed by production (fall between cracks).

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QUALITY MANAGEMENT

(Continued)

Q.A.=

The process of assuring by monitoring, review, testing that the Q.C.P. is being implemented.

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QUALITY MANAGEMENT

(Continued)

Q.M.=

The system that assures overall quality. Q.M. addresses design and construction but also contract review and training. Functions are audit + surveillance.

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PROJECT Q.M. EXAMPLE

Quality Control **during the construction phase will be the responsibility of each Subcontractor carrying out a specific part of the works. The Subcontractor shall complete the appropriate checklist provided in this document and submit the forms to the Joint Venture Quality Administrator for approval.**

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PROJECT Q.M. EXAMPLE

(continued)

Quality Assurance **will be carried out by the subconsultant responsible for a specific part of the works. The subconsultant shall complete the appropriate checklists provided in this document and submit the form to the Quality Administrator for approval. In general, the forms shall be submitted for approval prior to commencement of the work or as specific in the forms.**

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PROJECT Q.M. EXAMPLE

(continued)

Validation **that the constructed works conform with the requirements of the design shall be the responsibility of the design consultant.**

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ELEMENTS OF Q.M.

Require ISO 9001 Certification

Require Certified Suppliers

- testing lab (A283)
- pre-cast (A251)
- steel fabricator (W59)

Specification

- certified product (eg. UL approved)
- epoxy bar (CRSI)

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PRACTICAL PROBLEMS

- Much rationalization to accept non-conforming products
- Contractors:
  - do not want to do Q.C.
  - are not experienced in Q.C.
- Job too small to implement Q.C. (and Q.M.)
- Increased soft costs

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POSITION OF S.E.

- Must rely on Q.A. by others
- Must do sufficient site reviews to provide Letter of Assurance per APEGBC = validation
- But an integrated Q.M. can be effective. The S.E. would rely on a review of:
  - Contractor Q.C.Ps. And Owner Q.A.P.
  - (on site) check lists, mill certificates, submittals
  - Q.A. Summary Reports
  - Surveillance and Audit Reports

  and their own site reviews.

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SUSTAINABILITY IN CANADA

- **Canada agreed at Kyoto to reduce its GHG emissions 6% below 1990 levels by 2010.**

- **Current projections are that the 2010 levels will miss the commitment by 25%.**

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The APEGBC has decreed that Engineers should consider sustainability in their designs and materials selections. Their Guidelines for Sustainability requires:

- ***Take into account the direct and indirect consequences.***
- ***Assess reasonable alternative concepts, design and methodologies.***
- ***Cooperate with colleagues, clients, employers, decision-makers and the public in the pursuit of sustainability.***

The concept presented here embraces this sustainability directly.

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THE CONCRETE INDUSTRY PERSPECTIVE

- Cement production results in 0.9T CO_2 for each T of cement produced.
- Cement produced » 14% of total industry CO_2 emission.
- There are 1.8 M^T of cement produced per year in B.C.
- So substituting a by-product (fly ash) for cement could have a major contribution.

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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%
- **World** — **500 M^T**
- **B.C uses** — **160,000T**

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DEVELOPMENT OF FA USE IN BC

- 1970 - Started
- 1985 - Commence research by CANMET on HVFA
- 1990 on to today - 15 to 20% cement replacement for ready-mix concrete as a general practice
- 1990 - Levelton introduced HVFA for mass footings (40%); now a common commercial product for this use. Mostly industrial
- Recent - a few special projects with (33%). The start of use in commercial, residential, institutional

THIS IS NOT NEW TECHNOLOGY

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ADVANTAGES TO USING FLY ASH

- Improves workability/pumpability of concrete so user friendly.
- Dilutes local “fast” cement.
- Reduces heat in mass concrete so reduces thermal cracking.
- Improves concrete’s resistance to chemical attack (sulphates).
- High long term strength.
- Slightly reduces shrinkage.
- Abates reactivity between cement and local reactive aggregates.

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RESTRAINT TO USE OF FLY ASH

1) Psychological
   - try something new = risk

2) Technical

3) Economic

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CHALLENGES

1) Overcome restraints.

2) Move the technology developed in industrial concrete to the major market volume in commercial /residential / institutional.

3) Raise the bar - get from the current norm of 15% to 20% to a readily achievable 30% to 35%.

4) Use 50% to 60% replacement for special structures.

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SOLUTION - PSYCHOLOGICAL

Move “labcrete” to real crete.

Do demonstration projects:

- **Willing Owner**
- **Willing Architect and Engineer**
- **Willing Contractor**
- **Willing Supplier**

Do up-front testing to qualify HVFA mixes (in footings?)

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SOLUTION - TECHNICAL

- **Mandate use in Standards and/or Specifications.**
- **HVFA concrete has slower setting and strength gain. Correct by raising temperature, adding accelerator, adding more total cementing materials.**
- **Use 56 day strength acceptance.**

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RESISTANCE BY CEMENT FINISHERS

- Difficult to finish
- Weak skin
- More variations in appearance if sandblasted
- Difficult to vibrate
- Increase finishing times (primarily in cold weather)

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SOLUTION - ECONOMIC

- cement costs $125.00/T
- fly ash cost $ 65.00/T

So if use a typical 300 kg/m^3 cement factor, can save » $9.00/ m^3 with 50% replacement.

But may increase these construction costs:

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

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LIU CENTRE MIX

- **Developed by Levelton/CANMET trial mix program.**
- ***Per Cubic Meter***

➢ **Cement**	**195 kg**
➢ **Fly ash**	**195 kg**
➢ **Sand**	**760 kg**
➢ **Stone, 20 mm**	**1080 kg**
➢ **Water**	**140 litres**
➢ **Admixture**	**Water reducing agent**

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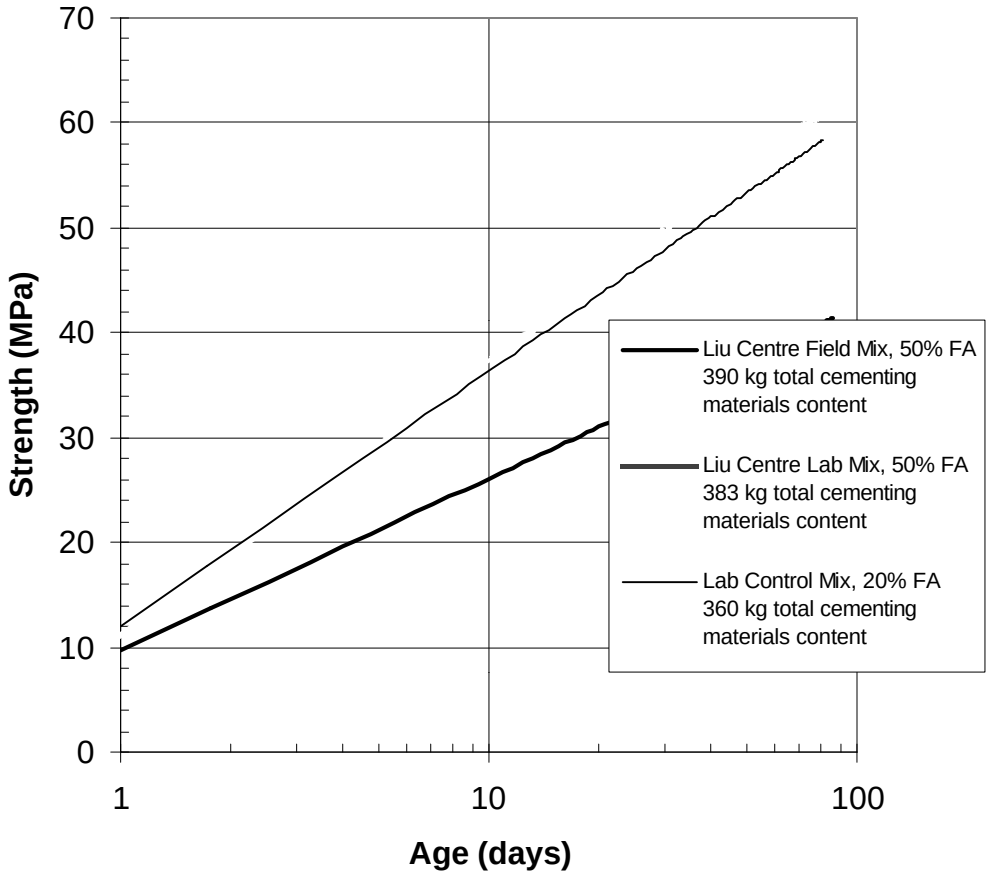
HVFA

Strength History Summary



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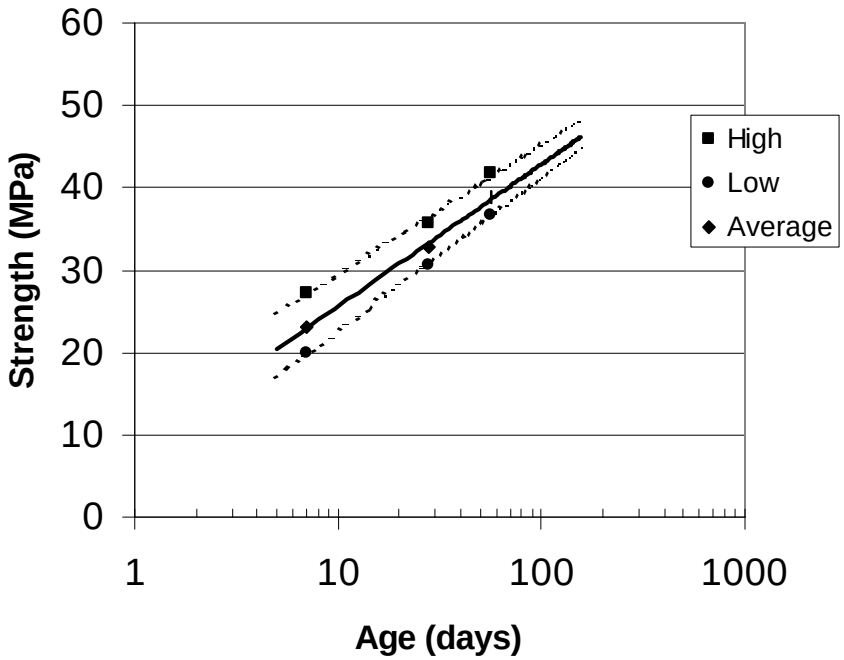
Lui Centre

Summary of 14 Field Tests



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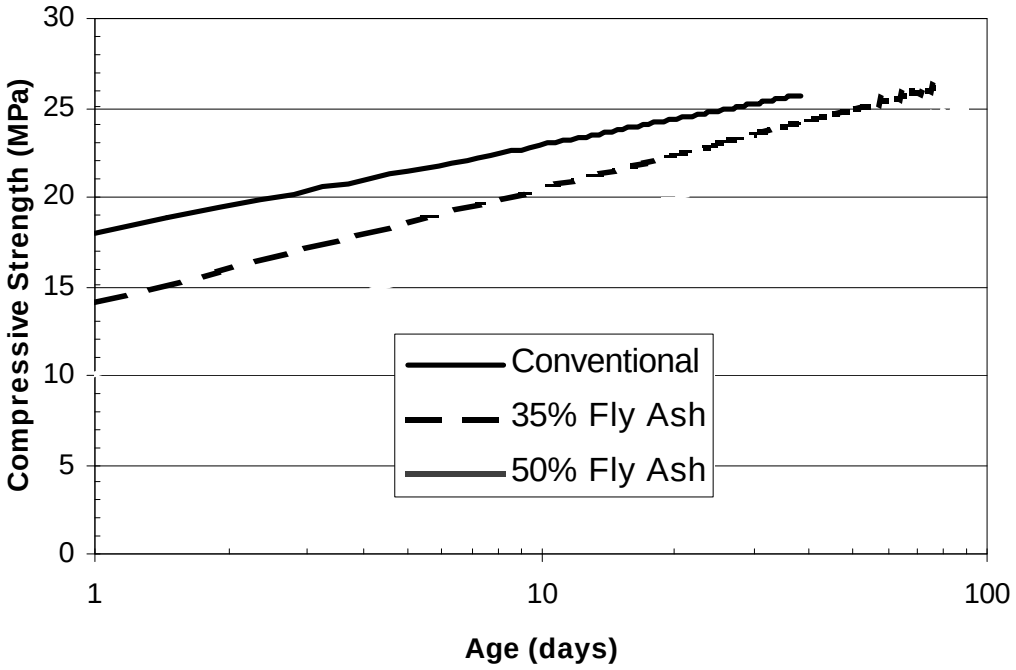
Idealized Age:Strength



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CURRENT PERSPECTIVE

- ***Immense local interest***
  - **Architects**
  - **Engineers**
  - **Concrete Suppliers**
  - **Precast Suppliers**
- ***Recent Projects***
  - **Pacific Press**
  - **B.C. Gas**
- ***Pending Projects***
  - **Developer high rise**
  - **RTP 2000**

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PENDING DEVELOPMENTS

- **Supply of blended cement.**
- **Mandate by PWSCC.**
- **Mandate by School Boards (3 in Interior).**

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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%

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HOW TO IMPLEMENT HVFA ON A PROJECT

Change Specification:

- In “General”, state intent to use HVFA
- Add reference to CSA A23.5 - Class F
- Mandate % FA replacement

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HOW TO IMPLEMENT HVFA ON A PROJECT

(Continued)

Tendering:

- **"…lump sum credit for release from mandated fly ash requirements".**
- **Separate pay item for curing.**

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HOW TO IMPLEMENT HVFA ON A PROJECT

(Continued)

Include in Field Practice:

- **Mock-up panel for architectural concrete.**
- **Trials during footing concreting.**
- **Cure minimum 5 days.**

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SERVICE LIFE MODELLING - Cl`

All based on Fick's Second Law

$$C_{x,\ t} = Co\ [1 - Erf\ \{ x/2\ (t\ D)\ 1/2\}]$$

Types available

- **Grace**
- **Master Builders**
- **NIST**
- **ACI**
- **University of Toronto**

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SERVICE LIFE MODELLING - Cl`

(Continued)

Should address these variables:

- RH
- Temperature
- Resistivity
- Sorptivity (covercrete)
- Differential electrical potential
- Boundary conditions

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OTHER

- **New Grace fiber development**
  - **Potential to reduce shrinkage cracking**
  - **Add shear strength**
- **Some interest in non-metallic reinforcing**
- **Some interest in external reinforcing**

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HPC

- Current commercial maximum = 60 MPa
- With special care, 80 - 100 MPa
- Can get at any age, but best if use 90 day
- For some Ec is important
- For some f_t is important
- Curing (2 stage) critical

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THANK YOU

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