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Current Situation of SCMs in Canada

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Objectives

- Determine the current situation of SCMs in Canada:
 - ◆ **Production**
 - ◆ **Uses and quantity**
 - ◆ **Barriers (policy, technical, economic, others)**
 - ◆ **Suggestions to overcome the barriers**
- Identify a strategy plan to increase the use of SCMs in Canada, thus contributing to the reduction of CO₂ emissions.

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SCMs Production in Canada

SCM	Production level 2001	Useable as SCM
Fly Ash	~ 4,800,000	~ 2,200,000
BFS	1,438,000	380,000 (GGBFS)
Silica Fume	20,000	20,000

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Location of the sources of Useable SCMs in Canada



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SCMs used in Concrete Applications (separate ingredients)

SCM	Reasons for use	Quantity, tonnes	% replac.
Fly Ash	Cost, performance	450,000	10-25
Slag		216,000	15-40
Silica Fume	Durability	3,350	5-12

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Fly Ash Concrete Applications (as a separate ingredient)

Applications	%	Quantity, m ³
Residential	36.9	165,700
Comm./Ind./Inst.	52.5	236,000
Infrastructure	10.3	46,500
Special	0.3	1,150

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Slag Concrete Applications (as a separate ingredient)

Applications	%	Quantity, m ³
Residential	16.7	36,000
Comm./Ind./Inst.	66.6	144,000
Infrastructure	16.7	36,000

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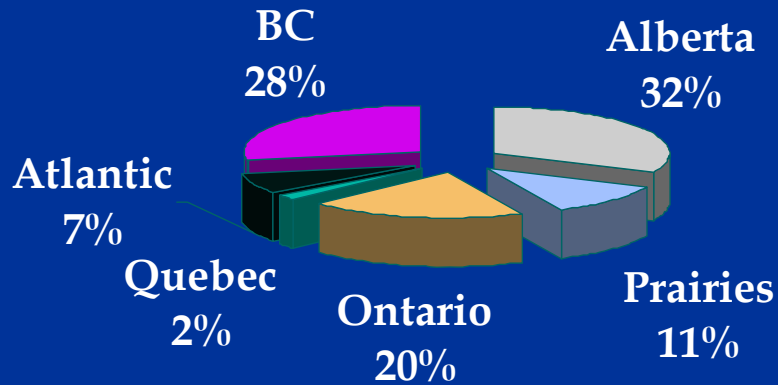
Silica Fume Concrete Applications (as a separate ingredient)

Applications	%	Quantity, m ³
Infrastructure	92.5	3,100
Special	7.5	250

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Percentage of Fly Ash used in Concrete in each Region



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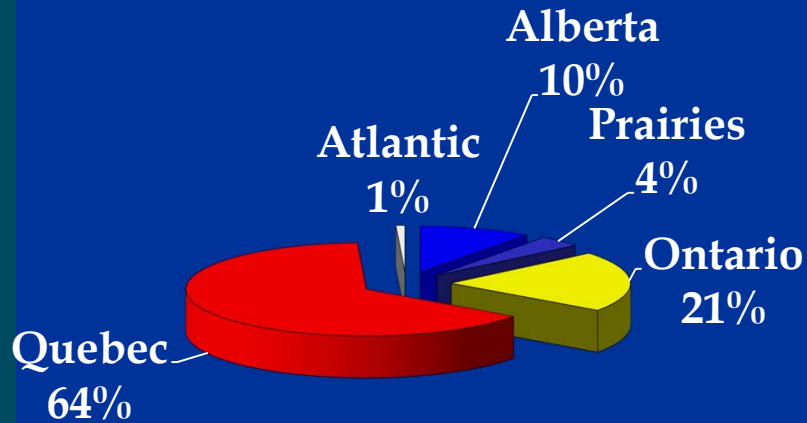
SCM used in Blended Cements

SCM	Type	Tonnes
Fly Ash	Ternary cement	10,000
Slag	Ternary cement	11,000
Silica Fume	Binary cement	19,000

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Percentage of SCM used in Blended Cement in each Region



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Other SCMs Applications

SCM	Applications	Tonnes
Fly Ash	Grouts, Mortars, Repair Products, Mining, Oil Cement	65,000
Slag		120,000
Silica Fume		15,000

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Total Amount of SCMs Used

	Fly Ash	GGBFS	Silica Fume
Production	4,800,000	380,000	20,000
Useable	2,200,000	380,000	20,000
Concrete	450,000	215,000	3,350
Blended C.	10,000	12,000	19,400
Other App.	65,000	120,000	14,650
Total	525,000	347,000	37,400

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Quantity of Concrete Produced in Manitoba

Applications		Quantity of concrete in 2001 in m ³
Residential	35%	159,000
Commercial/industrial	40%	182,000
Infrastructure	25%	114,000
Total	100%	455,000

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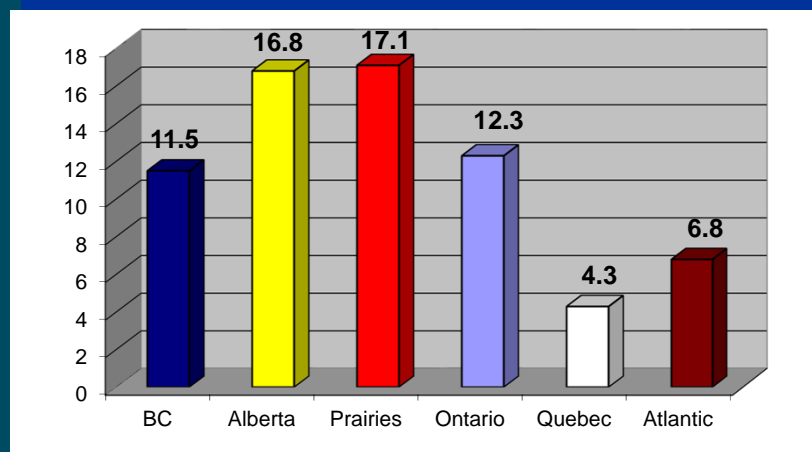
Quantity of Fly Ash used in Manitoba

Applications	Quantity of fly ash, tonnes	% Fly Ash
Residential	10,000	25%
Commercial/ industrial	11,000	20%
Infrastructure	4,500	10%
Total	25,500	

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Percentage of SCMs to the quantity of Cement used in each Region



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Policy Barriers

- Quebec
 - ◆ **City of Quebec does not allow the use of fly ash in sidewalks.**
 - ◆ **It is stated in the guidelines of Hydro Quebec that the use of SCMs is not permitted.**
- Ontario
 - ◆ **In Ontario Provincial Standard Specification OPSS 1350, under Cementing Materials Clause, the following restrictions are given:**
 - *Slag up to 25%*
 - *Fly Ash up to 10%*

Policy Barriers (Con't)

- Alberta
 - ◆ **Alberta Transportation: the use of fly ash is not permitted in highway construction.**
 - ◆ **Alberta Infrastructure: fly ash should not be used in concrete subjected to freeze-thaw cycles, or de-icing salts**
- Prairies
 - ◆ **Manitoba Highways does not allow the use of fly ash in some elements.**
 - ◆ **City of Winnipeg: (Pavements) maximum of 15% fly ash is permitted between May 2 and Sept. 14, and 10% between Sept. 15 and Oct. 1, and 0% between Oct. 1 and May 1.**

Technical Barriers

- Freezing and thawing and/or de-icing salt scaling resistance of fly ash concrete.
- Finishing operations when ~ large amounts of fly ash are used in concrete flatwork.
- Slower set / early-age strength development of concrete containing fly ash or slag.

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Scaling Resistance

→ MTQ experience with Ternary cement in pavements:

- No visual scaling was observed after 5 years.



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Performance of Fly Ash Sidewalks in Montreal

Field Evaluation after 3 winters (35% fly ash)



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Technical Barriers

- Freezing and thawing and/or de-icing salt scaling resistance of fly ash concrete.
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Economic Barriers

- Cost of transportation in remote area.
- Cost of silo for small companies.

Suggestions to overcome the Barriers

- Develop clear specifications/guidelines for the use of SCMs in cement and concrete. The specifications/guidelines must be agreed upon by all interested parties and must be issued under the auspices of CSA.
- Organize workshops in different cities of Canada with a major effort being made to get all the involved parties to attend in order to adopt the developed guidelines.

Suggestions to overcome the Barriers (Con't)

- Organize forums to discuss ways to resolve technical issues.

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Use of Fly Ash and Slag in Concrete: A Best Practice Guide

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Affiliations and Individuals Involved

- ARMCA
- CAC
- CANMET
- CIRCA
- CRMCA
- PWGSC
- RMCAO
- CCAP 2000
- P.K. Smith International (finisher)
- Yolles Engineering Solutions (designer)
- J.A. Bickley and Associates Ltd (consultant)
- Ellis-Don Construction Ltd (contractor)
- Concrete Floor Contractors Association of Ontario

Reviewers: R.D. Hooton, W.S. Langley, D.R. Morgan, P.T. Seabrook, and M.D.A. Thomas

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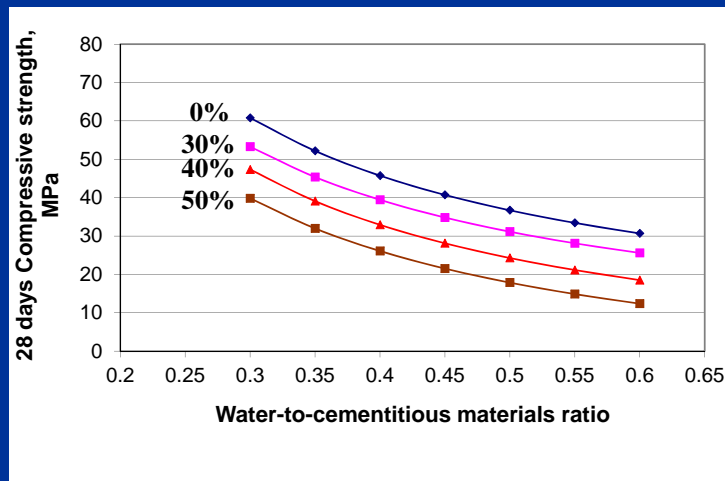
Concrete Mixture Proportions

- The procedure for selection of mixture proportions used for portland cement concrete is also applicable to concrete incorporating fly ash or slag with some modifications.
 - ◆ Estimation of mixing water should account for the effect of fly ash and slag on the water demand of concrete.
 - ◆ Selection of w/cm. In general, to achieve similar early-age strength (up to 28 days) as a portland cement concrete, fly ash and slag concrete might require lower w/cm and higher total weight of cementitious materials.

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Selection of W/CM



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Concrete Mixture Proportions

- ◆ It is mentioned in CSA A23.1-04 that for concrete in which the fly ash and slag contents satisfy the following equation $FA/40 + S/45 > 1$ (HVSCM1), the maximum W/CM of the concrete should meet the CSA requirements, except when the concrete is exposed to freezing and thawing in which case the CSA required values should be reduced by 0.05

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Concrete Mixture Proportions

Class of exposure	Not HVSCM1 concrete	HVSCM1 concrete exposed to freeze/thaw cycles
C-XL	0.37	0.32
C-1	0.40	0.35
C-2	0.45	0.40
F-1	0.50	0.45
F-2	0.55	0.50
A-1	0.40	0.35
A-2	0.45	0.40
A-3	0.50	0.45
S-1	0.40	0.35
S-2	0.45	0.40
S-3	0.50	0.45

Concrete Mixture Proportions

- ◆ For reinforced concrete elements exposed to moisture and air, with depths of cover less than 50 mm, the W/CM should not be greater than 0.40 for HVSCM1 ($FA/40 + S/45 > 1$) and not greater than 0.45 for HVSCM2 ($FA/30 + S/35 > 1$).

Concrete Mixture Proportions

- ◆ Fly ash and slag contents. It is recommended to use the following minimum percentages whenever it is technically and economically feasible.

	Cool weather		Hot weather	
	Type F/CI	Type CH or Slag	Type F/CI	Type CH or Slag
All app.	15	15	25	25
Mass Concrete	40	50	50	65 (slag)
Sulphate issues	20	35-55 (slag)	20	35-55 (slag)

Concrete Mixture Proportions

	Cold weather		Hot weather	
	Type F/CI	Type CH or Slag	Type F/CI	Type CH or Slag
ASR issues	20-35	35 (slag)	20-35	35 (slag)
CSA Class C1 (except hand finishing)	30	30	30	30
Hand finishing concrete exposed to freeze/thaw and deicing	Max. 25	Max. 35	Max. 35	Max. 50

Finishing of SCMs Concrete

- Moderate levels of SCMs (15 to 25%)

It is the general view of finishers that the use of moderate levels of SCMs makes the finishing of concrete slabs easier due to the increase of workability and the volume of paste.

Finishing of SCMs Concrete

- High levels of SCMs (> 30 to 35%)
 - ◆ Concrete with low W/CM, and incorporating high volumes of SCMs can present problems with finishability due to low bleed water.
 - ◆ By utilizing a fog spray, evaporative inhibitor or midrange water reducer, the surface water sheen can be replenished and the lack of moisture that results in finishing difficulties can be significantly reduced.

Finishing of SCMs Concrete

- Slabs exposed to a combination of chlorides and freeze/thaw cycles
 - ◆ Wait until bleeding is stopped before final finishing
 - ◆ Use minimal working of the surface during finishing
 - ◆ Apply curing after final finish
 - ◆ If it is not possible to allow 1-month of "maturing" before first freeze or salt application, then use a minimum amount of SCM.

Curing of SCMs Concrete

Allowable curing regimes according to CSA A 23.1-04

Curing regime	Name	Description
1	Basic	3 d at $\geq 10^{\circ}\text{C}$ or for a time necessary to attain 40% of the specified strength.
2	Additional	7 d at $\geq 10^{\circ}\text{C}$ and for a time necessary to attain 70% of the specified strength
3	Extended	A wet curing period of 7 d.

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Curing of SCMs Concrete

Class of exposure	Not HVSCM concrete	HVSCM2	HVSCM1
C-XL	3	3	3
C-1 or A-1	2	2	3
C-2 or A-2	1	2	2
C-3 or A-3	1	2	2
C-4 or A-4	1	2	2
F-1	2	2	3
F-2	1	2	2
N	1	2	2
S-1	2	2	3
S-2	2	2	3
S-3	1	2	2

Curing of SCMs Concrete

- Although there is no difference in specified curing for conventional concrete and SCM concrete (SCM contents less than 30 to 35%), the SCM concrete must be cured (as specified) as it is less forgiving than conventional concrete.