Natural Resources Canada | Ressources naturelles Canada

Current Situation of SCMs in Canada

N. Bouzoubaâ and B. Fournier

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 CO_2 emissions.

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

Location of the sources of Useable SCMs in Canada

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

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

Slag Concrete Applications (as a separate ingredient)

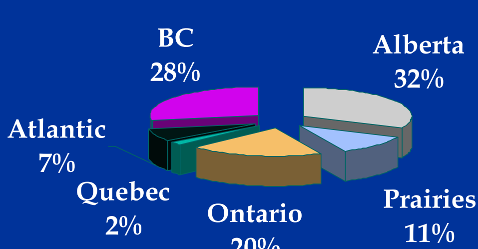
Applications	%	Quantity, m^3
Residential	16.7	36,000
Comm./Ind./Inst.	66.6	144,000
Infrastructure	16.7	36,000

Silica Fume Concrete Applications (as a separate ingredient)

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

CANMET Materials Technology Laboratory
Laboratoire de la technologie des matériaux Canada

Percentage of Fly Ash used in Concrete in each Region

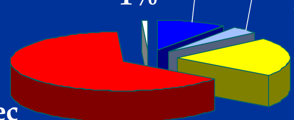


CANMET Materials Technology Laboratory
Laboratoire de la technologie des matériaux Canada

SCM used in Blended Cements

SCM	Type	Tonnes
Fly Ash	20E-F/SF 10E-F	10,000
Slag	10E-S/SF 10E-S	11,000
Silica Fume	LASF 10-E-SF	19,000

Percentage of SCM used in Blended Cement in each Region



Other SCMs Applications

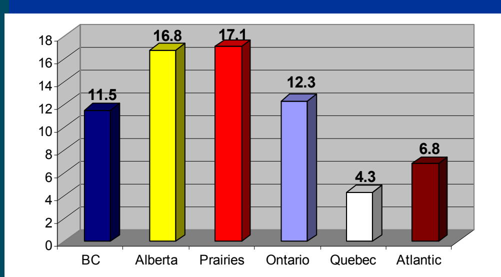
SCM	Applications	Tonnes
Fly Ash	Grouts, Mortars, Repair Products, Mining, Oil Cement	65,000
Slag		120,000
Silica Fume		15,000

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

CANMET Materials Technology Laboratory
Laboratoire de la technologie des matériaux
Canada

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



CANMET Materials Technology Laboratory
Laboratoire de la technologie des matériaux
Canada

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%*

CANMET Materials Technology Laboratory
Laboratoire de la technologie des matériaux
Canada

Policy Barriers (Con't)

- Prairies
  - **Manitoba Highways does not allow the use of fly ash in some elements.**
  - **City of Winnipeg: up to 10% fly ash is permitted in bridge decks; in pavements, maximum of 15% fly ash is permitted between May 2 and Sept. 14, and 0% between Oct. 1 and May 1.**
- 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.**

Policy Barriers (Con't)

- City of Edmonton: in general, the city allows the use of a maximum 10% fly ash content.
- City of Calgary: the city requires a minimum cement content precluding the use of fly ash in concrete sidewalks, curbs and gutters.

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.
- Quality of fly ash in Atlantic Canada, and in southern Ontario (12-16% of free carbon).

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.

Natural Resources Canada | Ressources naturelles Canada

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

N. Bouzoubaâ and S. Foo

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

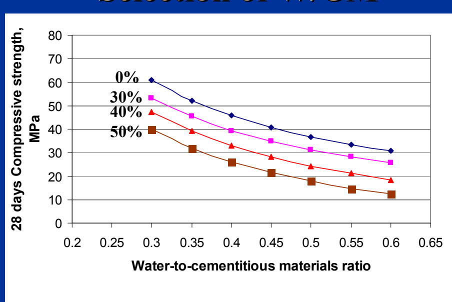
Table of Content

- Materials
- Concrete Design Considerations
- Concrete Mixture Proportions
- Production and Placing of Concrete
- Curing
- Quality Control of Concrete Incorporating SCMs

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.

Selection of W/CM



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

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.

CANMET Materials Technology Laboratory
Laboratoire de la technologie des matériaux
Canada

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 ≥ 10°C or for a time necessary to attain 40% of the specified strength.
2	Additional	7 d at ≥ 10°C and for a time necessary to attain 70% of the specified strength
3	Extended	A wet curing period of 7 d.

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.