

# **ECOSMART™ CONCRETE Project**

## **a concrete contribution to the environment™**

**Ecosmart 混凝土计划**  
**混凝土对环境的贡献**

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### **Low-Carbon Concrete:**

**Greener, More Economical, Higher Quality**

**低碳混凝土-更绿色，更经济，更质优**

**Michel de Spot, P.Eng.**

*President & CEO,*

**ECOSMART Foundation**

**China, Fall 2010**

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# EcoSmart™ Foundation

## 项目基础

Non-profit organization created in 1999.

作为非营利组织成立于**1999**。

Supported by the Government of Canada.

获得加拿大政府支持。

Introduce technology innovations that reduce GHG emission for example in concrete.

提出可降低混凝土生产中温室气体排放量的创新科技。

MOU signed with CABR in the context of China-Canada Climate Change agreement.

与中国建筑科学研究院签署备忘录。



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# Canada China MOU on Climate Change

## 中加气候变化合作谅解备忘录



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# One tonne Clinker, one tonne CO<sub>2</sub>

50% Process 过程

40% Fuel 燃料

10% Electricity, 电力

Transportation 运输



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# GHG from Cement

## 水泥工业生产的温室气体

### World 全球范围

- Total emissions: 2 Gt  $\text{CO}_2$ / yr
- 总计排放量 : 2 Gt  $\text{CO}_2$ /年

### China 中国

- About 1 Gt  $\text{CO}_2$  /yr or 47% of world Total
- 大约1 Gt  $\text{CO}_2$  /年 或 47% 的全球总量
- 40 Mt $\text{CO}_2$ /yr increase
- 增长速度: 40 Mt $\text{CO}_2$ /年

New GHG reduction target for China: 40 ~ 45% by 2020

到2020年中国温室气体减量目标 : 40 ~ 45%

注: Gt= $10^9$ 吨 ; Mt= $10^6$ 吨

# **GHG Reduction Strategies in cement manufacturing**

水泥工业的温室气体减排策略

1. Decrease energy intensity   减少能源消耗
  - diminishing returns   以此减排
2. Increase alternative fuel   增加替代燃料
  - only biofuels for CC offsets 仅当采用生物燃料可视为抵消
3. Increase the use of SCM (\*)   增加SCM的使用
  - pre-blended at the plant 在水泥厂预先混合生产
  - added in the concrete mix 在混凝土拌合料中加入

(\*) Supplementary Cementing Material 辅助胶凝材料

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# SCM 辅助胶凝材料



Fly Ash  
粉煤灰

Ground Granulated Blast Furnace Slag  
**ECOSMART™ CONCRETE**  
磨细高炉矿渣  
A Concrete C



# SCM

## 辅助胶凝材料

Natural Pozzolan  
天然火山灰



Metakaolin  
偏高岭土



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# SCM 辅助胶凝材料

SCM 辅助胶凝材料	Source 来源	Type 类型	Activity 活性	Cost 成本	Availability 获取难易
Fly Ash 粉煤灰	Power 发电	Pozz 火山灰质	Med 中等	Med-low	High 容易
GGBFS 矿渣粉	Steel 炼钢	Hydro 水化活性	High 高	Med	Med 一般
Micro Silica 微硅粉	Silica 硅	Pozz 火山灰质	Very High 非常高	Very High	Low 难
Pozzolan 火山灰	Geo 天然	Pozz 火山灰质	Low 低	Low	Regional 地域受限
Metakaolin 偏高岭土	Oil / Geo 石油/天然	Pozz 火山灰质	Very High 非常高	High	? 未知
Limestone 石灰石	Geo 天然	Filler 填料	n/a 未知	Low	High 容易

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# Portland Cement Standard – China

## 中国硅酸盐水泥标准

Portland Cement	P.I	100	---	---	---	---
	P.II	≥95	≤5	---	---	---
		≥95	----	----	----	≤5
Ordinary Portland Cement	P.O	≥80, <95		>5, ≤20		----
Portland Slag Cement	P.S.A	≥50, <80	>20, ≤50	----	----	----
	P.S.B	≥30, <50	>50, 70	----	----	----
Portland Pozzolana Cement	P.P	≥60, <80	----	>20, ≤40	----	----
Portland Fly ash Cement	P.F	≥60, <80	----	----	>20, ≤40	----
Composite Portland Cement	P.C	≥50, <80		>20, ≤50		

注：上述表格中第一列中由上至下依次为：硅酸盐水泥、普通硅酸盐水泥、矿渣

硅酸盐水泥、火山灰质硅酸盐水泥、粉煤灰硅酸盐水泥、复合硅酸盐水泥

# EcoSmart Concrete Objectives

EcoSmart 混凝土的目标

To minimize GHG “signature” of concrete  
by optimizing replacement of Portland cement with SCM  
while improving or maintaining

在改进与完善过程中，通过掺用辅助胶凝材料优化取代硅酸盐水泥，将混凝土的温室气体效应最小化。

- Cost 成本
- Performance 性能
- Constructability 施工性



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# 50% FA

50%的粉煤灰



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50% fly ash

# Precast Concrete

## 预制混凝土



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# Bayview High Rise Building

## 海景高层建筑

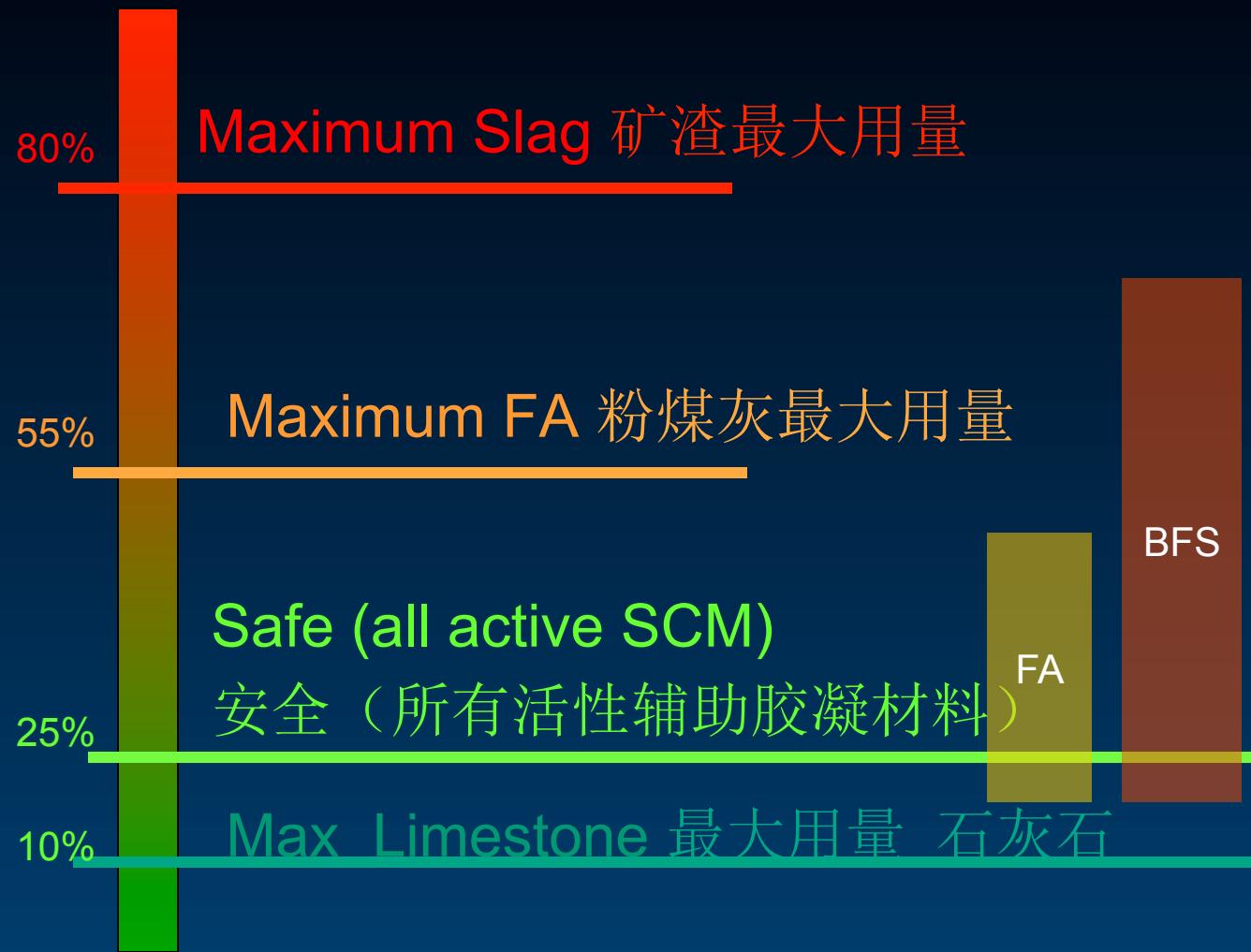
Element	Min. 28 Day Strength (mPa)	% flyash replacement (Ledcor Standard)	% flyash replacement (Actual)	W/CM
Parking Slabs & Slab Bands	35	15	33	0.40
Slab on Grade Interior Parking	25	20	20	0.50
Slab on Grade Exterior	32	20	20	0.45
Core Footing	30	40	45	0.50
Other Footings	25	40	45	0.50
Shear Walls & Columns				
<i>Foundation to 8th Floor</i>	40	15	33	0.45
<i>8th to 12th Floor</i>	35	15	33	0.45
<i>12th to 16th Floor</i>	30	20	33	0.45
<i>16th Floor to Roof &amp; Other Walls</i>	25	20	33	0.45
Tower Slabs	25	15	15 to 25	
Toppings & Housekeeping Pads	20	15	45	

注：上述表格中第一栏由左至右依次为：构件、最小28天强度、标准规定粉煤灰掺量、实际粉煤灰掺量、水灰比。第一列中为对应的具体构件。



# Replacement level

## 掺量水平



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# Parameters 要素

## Material 材料

Type of SCM 类型: FA, GGBFS, SF, other Cost 其他费用,

Availability 可利用性, distance 距离

## Technical 技术

Type of element 元素类型: slab 厚平板, walls 墙面, footings 地基, ..

Strength 强度: Stripping, 28d, 56d

Durability 耐用性, resistance to scaling 缩放的耐压性, exposure 曝光

Curing 养护, carbonation 碳化作用, Standards 技术规范,

Liability 责任

## Construction 建筑

Placing 地点, finishing 完工修整, forms 形式, curing 养护

Setting time 凝结时间: Stripping and finishing 拆模和完工

Architectural aspect 建筑角度: Color 颜色, texture 质地, finish 抛光

## Environment 环境

GHG Signature 特征信号, Waste reduction 废物减量,

Expected lifespan 预期生命周期

# Industry decision-makers

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## Supply 供应

- Cement Manufacturers 水泥制造商
- Ready-Mixed Concrete Producers 预拌混凝土产品
- SCM producers / suppliers SCM制造商/供应商

## Design 设计

- Developers 开发人员
- Architects 建筑师
- Structural Engineers 结构工程师
- Material engineers & test labs 材料工程师和实验室
- Code officials 编码官员

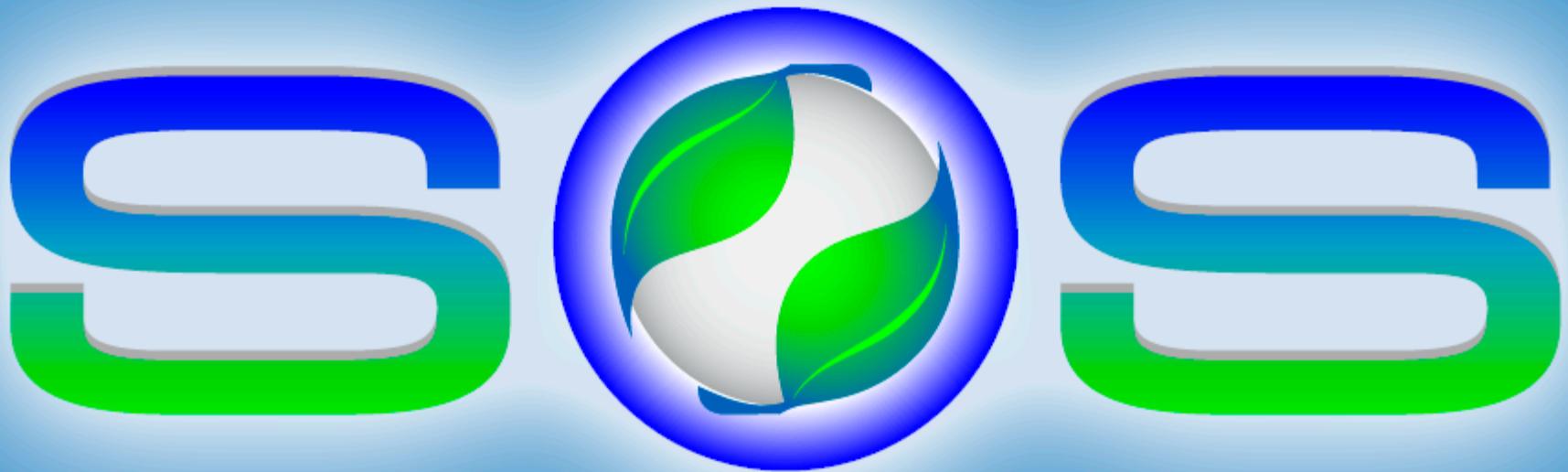
## Build 建造

- Contractors 承包商
- Sub-trades 配合商: Concrete placers 混凝土浇灌机

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**Supplementary Cementing Materials Optimization System**

**辅 助 胶 凝 材 料 优 化 系 统**



**SIMCO**  
Technologies inc.

**sos**  
**Consortium**

Non-profit organization promoting the increased use of SCM  
in "Green concrete"

推广增加辅助胶凝材料（SCM）在绿色混凝土中应  
用的非营利性组织

**Software Development Company**

**Concrete Infrastructure Management, Engineering**

**Life-Cycle Cost Analysis**

软件开发商

混凝土基础设施管理，工程全  
寿命成本分析



**20 Canadian organizations**

**Cement producers, contractors, architects, engineers,  
public organizations**

20个加拿大的组织

水泥生产商、承包商、建筑师、工程师、公共组织

# The Challenge 挑战



Supplementary Cementing Materials Optimization System

Use of SCM faces a number of challenges:

SCM的使用面临一系列的挑战：

- Lack of information on the pros and cons of SCM

缺乏关于SCM正面与负面的信息

- Improper training

缺乏正规的培训

- Regulations / Standards

规定/标准

- Bad experience

失败的经验

- Market inertia

市场反应不佳



*The successful use of SCM in concrete rests on knowledge sharing!*

成功的SCM应用基于知识的共享！

To develop a user-friendly web-based software that will facilitate « green concrete » by sharing information on the successful use of SCM.

开发出基于网络的用户友好型软件，通过分享SCM的成功使用经验促进“绿色混凝土”应用。



# The SOS Databases

## SOS数据库



Supplementary Cementing Materials Optimization System

User: jbethier      Logout

Structure: Industrial building      Help

Location: Quebec      Change Password

Connection Time: 00:01:03      Preferences

Analysis Type      Project Information

Select project: New Project 1

Project name: New Project 1

Project reference (facultative):

Location: Quebec Montreal

Schedule: 2/2/2010 4/30/2010

Structure: Industrial building

Element: Slab on grade

Manure or silage gases and liquids:

Municipal sewage or industrial effluent:

Exposure:  Exterior  Interior

Chloride exposure  Sulphate exposure

Structurally Reinforced  Saturated

Potentially reactive aggregate  Immersed

Montreal Weather Statistics

Legend: Daily average temperature (Grey), Daily max temperature (Red), Daily min temperature (Blue), Relative humidity (Green)

Graph showing Temperature (°C) and Humidity (%) from September to September. A vertical red shaded area covers January, February, and March, labeled 'Berlin' at the bottom.

Save Project Save Project As... SCM Increase Mode Previous Next

# The SOS Software

## SOS软件



Supplementary Cementing Materials Optimization System



Neural Network Model

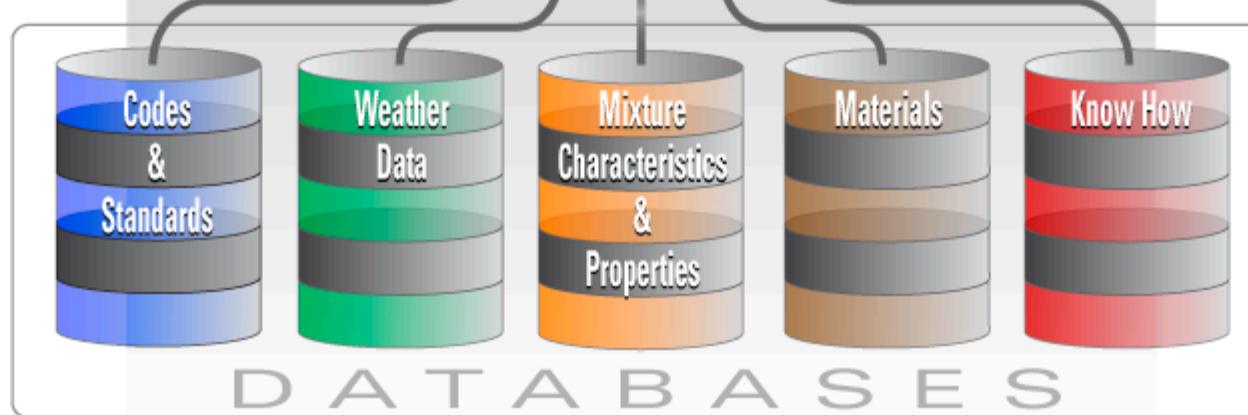
神经元网络模型

Empirical Equations

经验公式

Expert Guidance

专业指导意见



# The SOS Databases

## SOS数据库



Supplementary Cementing Materials Optimization System

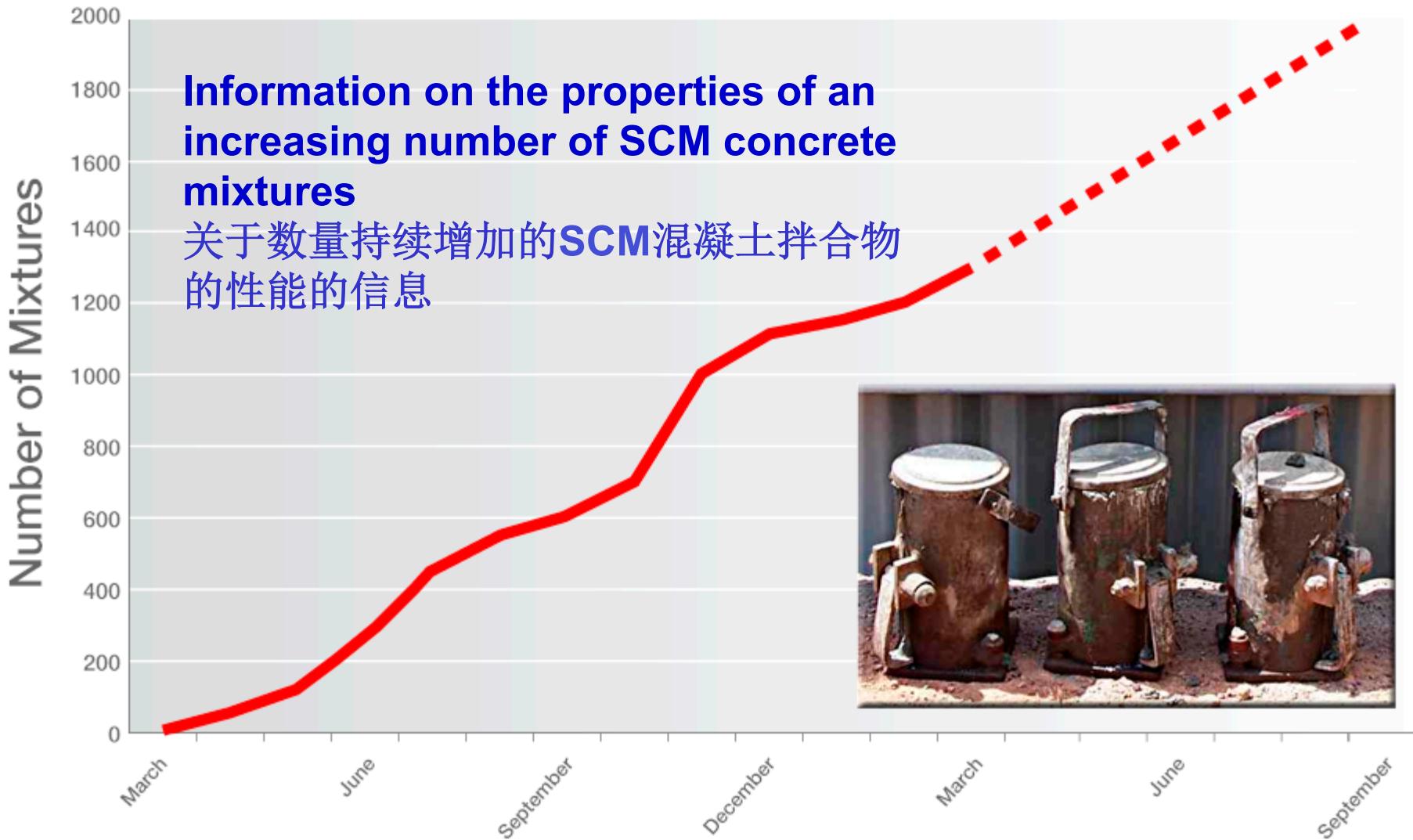


标准规范数据库



Information originating from more than 25 different technical documents published by different Canadian organizations

信息来源于由不同的加拿大组织发布的超过25的份技术文件



2009-2010

# A User-Friendly Interface

## 用户友好界面



Supplementary Cementing Materials Optimization System

User: jbethier  
Structure: Industrial building  
Location: Quebec  
Connection Time: 00:00:28

**SOS**  
Supplementary Cementing Materials Optimization System

Logout Help Change Password Preferences

Analysis Type Project Information Codes & Standards Specifications

Mix properties Strength and schedule Durability Cracking Curing Visual aspect and finish Codes Default Values:

**Mix characteristics**

Cement type	<input type="text"/>		
Projected SCM class	Type F Fly Ash		
Water-binder ratio	Min <input type="text"/>	Max <input type="text"/> 0.37	
SCM replacement level	Min <input type="text"/> %	Max <input type="text"/> 40	%
Paste content	Max <input type="text"/> %		
Max aggregate size	<input type="text"/> mm		
Sand/aggregate ratio	Min <input type="text"/>	Max <input type="text"/>	

**Fresh concrete properties**

Pumpability required	<input type="radio"/> Yes	<input checked="" type="radio"/> No
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Save Project Save Project As... SCM Increase Mode Previous Next

# Multiple User Modes

## 多用户模式



Supplementary Cementing Materials Optimization System

**Optimum SCM Volume**

优化的SCM用量

**Compliance with Specifications**

符合规范要求

**Theoretical Strength Development**

理论强度发展

**GHG Emission Reduction**

温室气体减排

**Cost Impact**

成本影响

**Appearance**

外观



**Optimized Carbon Footprint**

已优化碳排放的建筑



Literature Survey

文献调研



Expert Opinions

专家意见



Field Experience

现场经验



Expert Guidance, e.g.:

*« Cement replacement by fly ash may cause bleeding.  
This can be overcome by a reduction of the water-binder ratio. »*

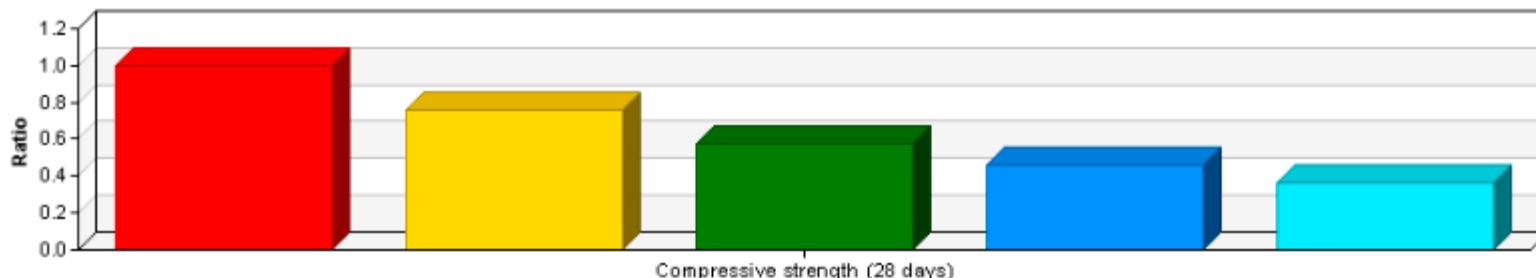
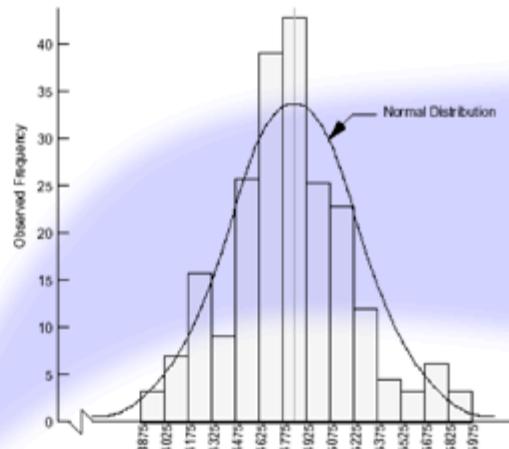
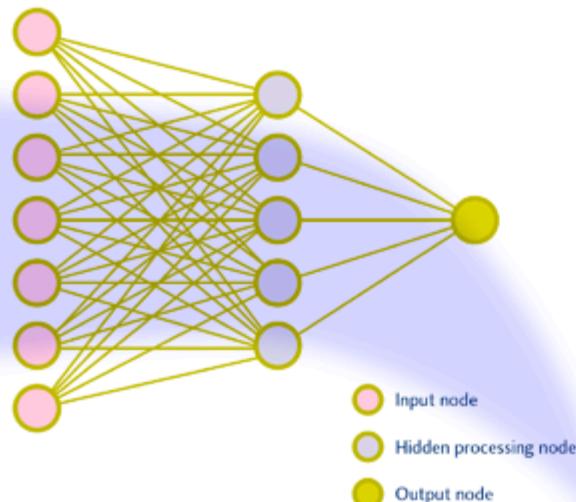
专业指导意见，诸如：掺用粉煤灰取代水泥可能导致泌水。可以通过降低水胶比克服。

# Output - Quantitative Data

输出 - 大量的数据



Supplementary Cementing Materials Optimization System



Scenario 1  
(Référence) :  
SCM % : 0

Scenario 2 :  
SCM % : 20

Scenario 3 :  
SCM % : 35

Scenario 4 :  
SCM % : 55

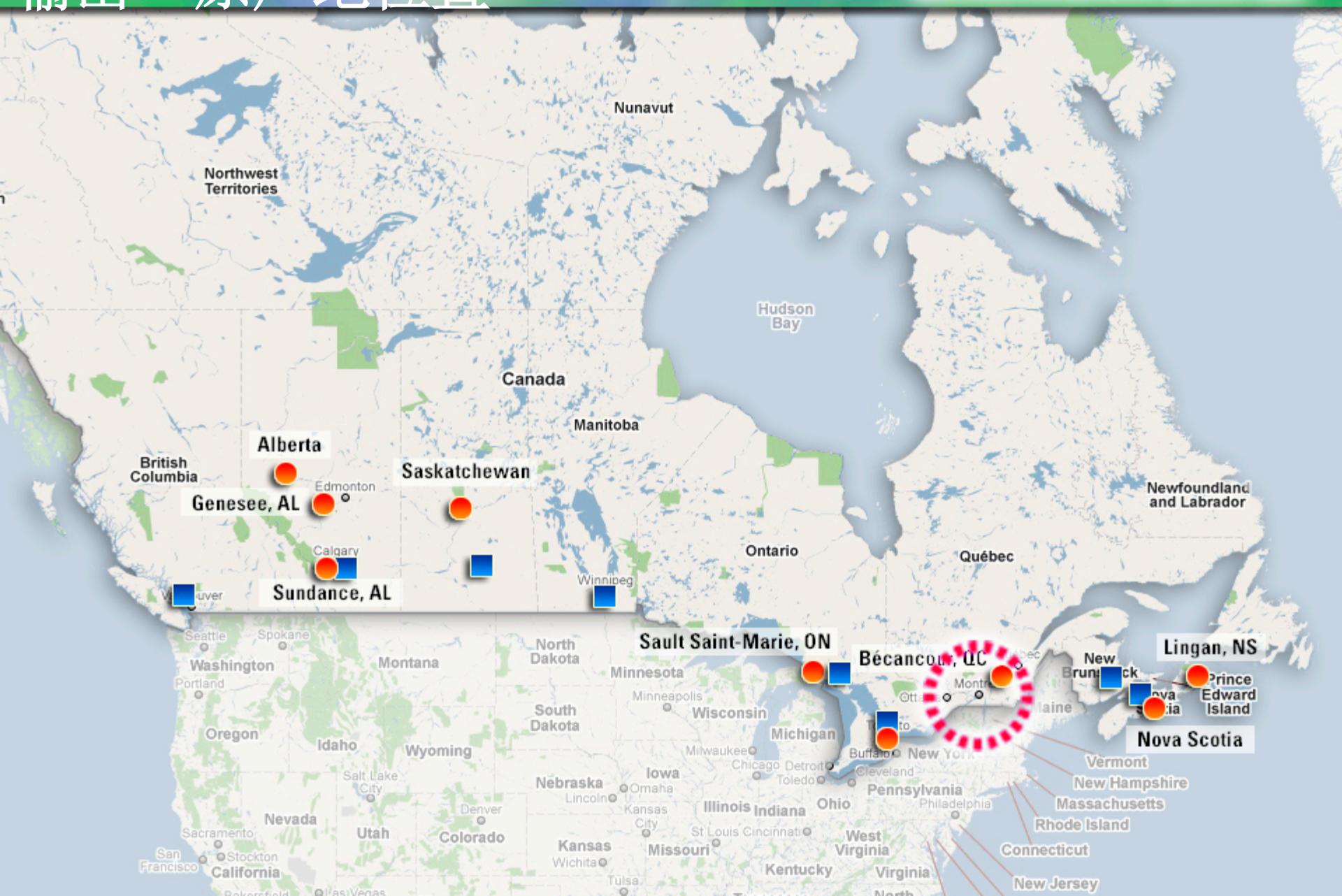
Scenario 5 :  
SCM % : 70

# Output - Source Location

## 输出—原产地位置



Supplementary Cementing Materials Optimization System



Context

Strategies  
&  
Solutions

Knowledge

Application  
to China

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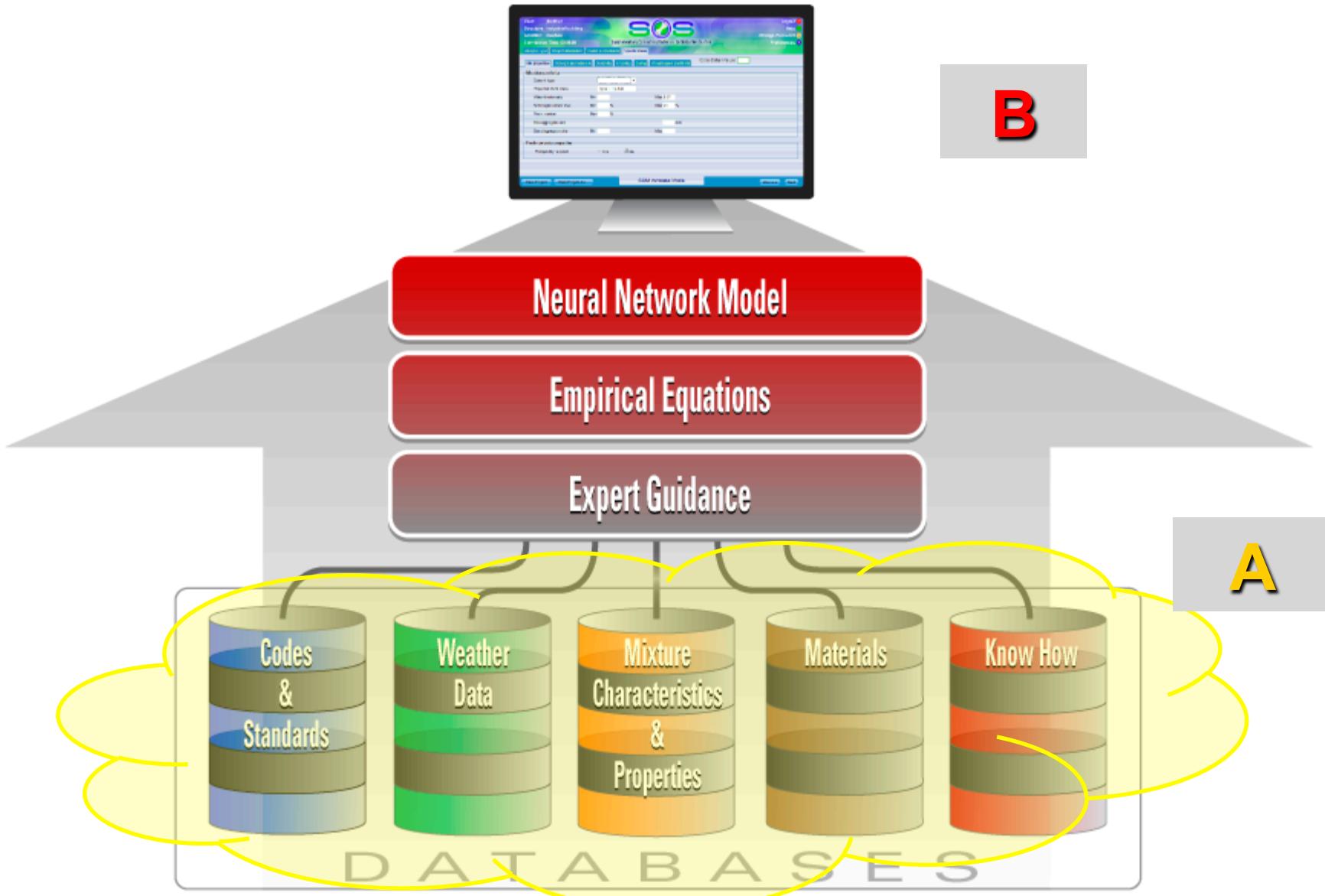
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# Application to China



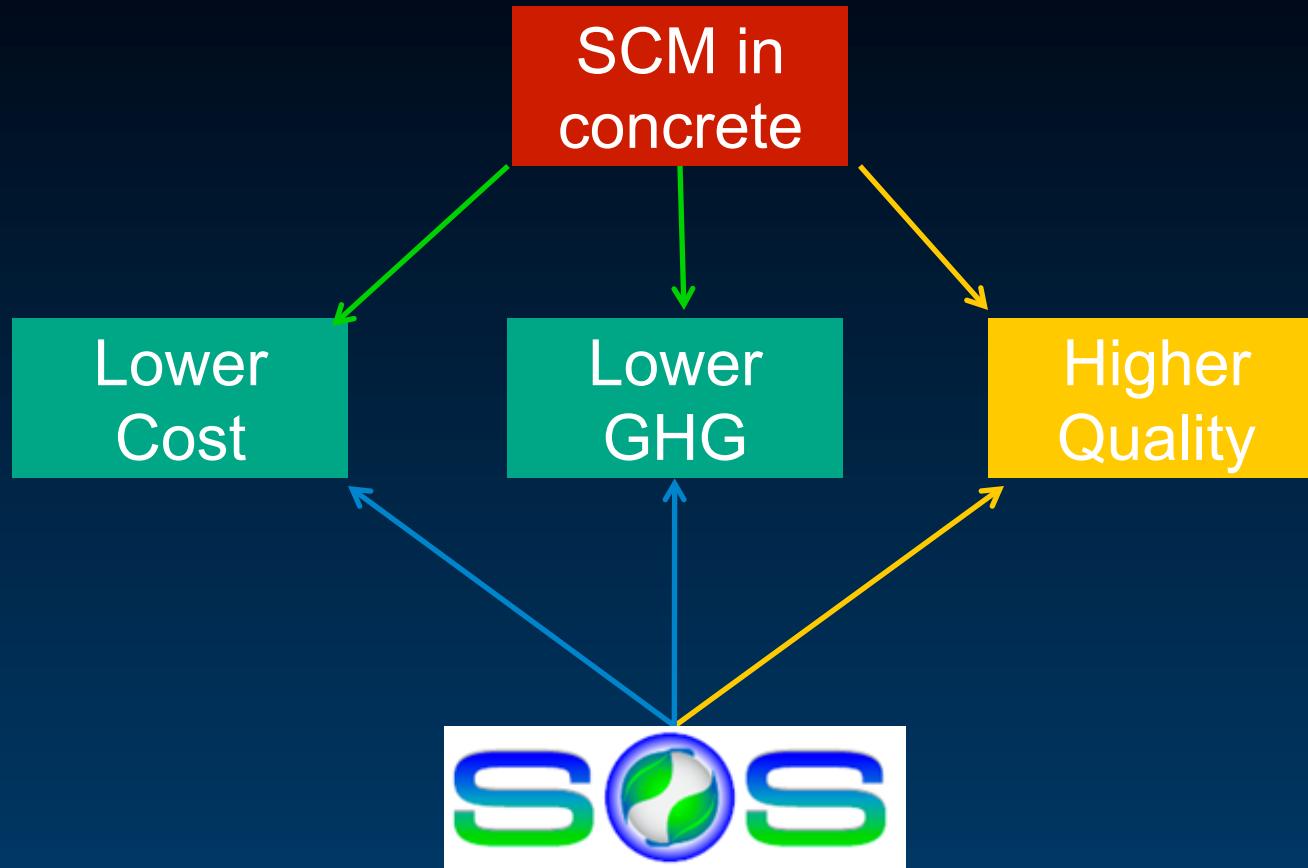
Supplementary Cementing Materials Optimization System



# Steps to Create China Databases



# Summary



# Thank You

Michel de Spot, P. Eng.  
*President & CEO,*  
***ECOSMART*** Foundation

[www.ecosmart.ca](http://www.ecosmart.ca)  
michel@ecosmart.ca  
*mobile (china) 13 55 29 56 11 63*

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