Transferring High Volume Supplementary Cementing Material (HVSCM) Technology to China
Background

Current HVSCM project in Canada

A key Canadian initiative in addressing the issue of Green House Gas emissions related to cement and concrete is the development of the SOS program. The SCM Optimization System (SOS) project - led by EcoSmart and involving a consortium of Canadian universities, cement companies, government organizations, engineering and construction companies, architects and developers – aims to develop a web-based computer application to provide online expert guidance concerning all aspects of performance of concrete structures that incorporate Supplementary Cementing Materials (SCMs) at all stages of design and construction – through concept, structural design, materials selection and proportioning, to construction management and implementation.

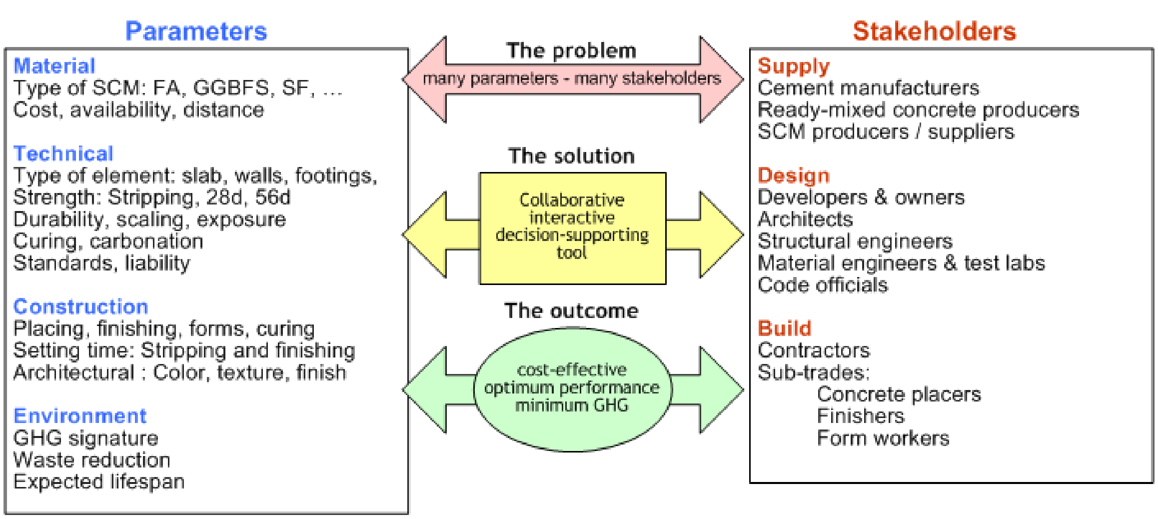
Rationale

The use of SCMs – such as fly ash, ground granulated blast furnace slag, micro-silica - or non-SCM such as limestone in concrete is increasingly becoming an important strategy for reducing the GHG (greenhouse gas) footprint of cement. In most cases, the use of SCM in concrete is a win-win solution: it reduces the cost of material and energy consumption, addresses local shortage of Portland cement, improves the concrete performance and workability, and reduces the overall concrete GHG signature.

Although using SCM in concrete offers is a solution that offers numerous benefits, it presents at the same time some challenges, such as longer setting time or potential effect on long-ter concrete durability. Designing and building with SCM concrete is a complex process that involves numerous interrelated, and often contradictory, parameters and a vast range of stakeholders, each with their own priorities and objectives, as illustrated in Figure 1.

The SOS was born out of a need for a tool to optimize the performance of concrete structures,

Figure 1: Decision process



now that most of them incorporate or will incorporate SCM, through a systematic, collaborative, interactive process that takes into account the complexity of both sides of the equation: (1) the scientific, technical, economical, and environmental parameters and (2) the multi-stakeholder decision-making process related to concrete and construction in general. Referring to Figure 1:

a) Building with concrete depends on many parameters (in the left box) that have different, often conflicting - priorities for the many stakeholders (in the right box) involved in a project.
b) The proposed solution is to develop a collaborative decision-supporting tool allowing the stakeholders to interactively optimize these parameters.
c) The objective is to determine for a particular project the concrete with the lowest cost, - optimized for all stakeholders - the highest technical performance and the lowest GHG signature within the context of a particular project.

The result will be better, more “sustainable” concrete construction through better understanding of the material and better collaboration between the various parties involved in the project.

Project Objective

The SOS is a decision-making system that enables optimizing the performance of concrete structures that incorporate SCMs. The primary objective of the SOS project is to assemble and package the scientific and technical knowledge, experience and intellectual property currently owned by the members of the partnership and that may have been used in previous case studies, and make these readily available to industry through a computer-based advisory / expert system.

The intent is that developers, builders, suppliers, architects and engineers will access the model and the database – which will be continuously updated with new scientific, technical and project data – and use it to determine the optimal specification for their projects. The model will take into account climate, structural specifications, construction requirements, quality of locally available materials, and numerous other parameters to determine not only optimal SCM levels but also cost savings and benefits in reduced GHG and criteria air contaminant (CAC) emissions. The system will give advice and guidance about performance, suitability for purpose, selection of materials, mix proportions, construction practices, code requirements, economic and technological alternatives, and mitigation of risk. In addition, the tool will interface with other software programs commonly used by industry.

Benefits

The SOS will provide substantial competitive advantages to its users, including reduced construction costs, better design and material specifications, optimized concrete performance, better understanding on construction impact, advice on how to avoid construction pitfalls and difficulties, support for green building design, LEED credits and GHG signature assessment, fast access to results of new research and fast-track transfer of knowledge and expertise from case studies.

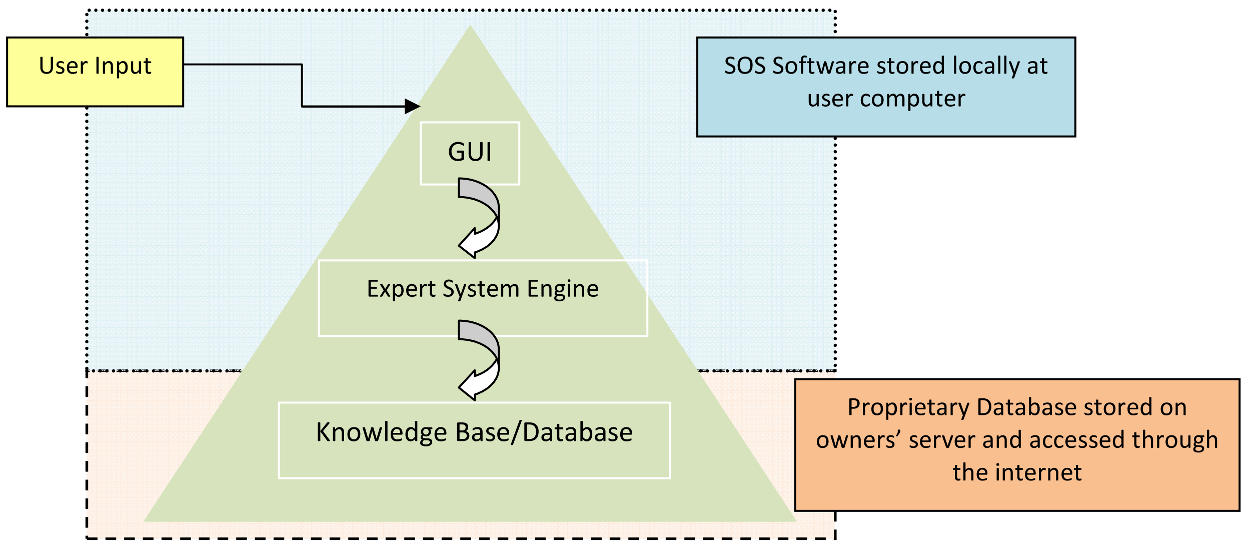
In summary, the SOS tool will make the industry more competitive and profitable by providing a tool to build better with concrete; as well it will help the construction industry persuade governments that concrete is a preferred building material in the modern drive towards sustainability.

Outline of the SOS application

The SOS software system has three main parts, or modules:

1. A web-based graphical user interface (GUI).
2. An expert system engine with optimization algorithms, dynamic modeling and artificial intelligence and user guidance system.
3. A knowledge base/database module providing supporting data and the technical foundation of the model. This model will be maintained centrally, and updated on an ongoing basis to ensure that it reflects current knowledge.

Figure 2: SOS Modules



Graphical User Interface (GUI)

The GUI module deals with the input of data for a given project, as well as provides output for the user. Input and output may include technical, economical and environmental data such as:

- Type of element (slabs, walls, footings, columns)
- Strength requirements (stripping, setting time, 28-day, 56-day, etc.)
- Durability requirements (resistance to scaling, resistance to chloride and sulfate attack, resistance to carbonation)
- Expected lifespan
- Curing requirements
- Location and climatic information; construction seasons
- Local availability of material, including blended cement
- Applicable building codes, standards, and specifications
- Placing, stripping, and finishing requirements

In some cases, input/output can be interchangeable: for example, the user may require an expected strength, or want to receive this information from the system. The interaction between the GUI and the Expert System Engine will be either iterative or use a simple input-output approach.

Expert System Engine

The Expert System draws on input data from the GUI and the information in the knowledge base/database to provide the guidance required by the user. This will be done in five parts:

1. Identify requirements/specifications for the concrete elements based on the input data provided by the user.
2. Optimize the content in one or multiple types of SCMs in order to produce a concrete mixture range that will meet all requirements and specifications while minimizing the carbon footprint of the project.
   (Note, however, that the SOS is not intended to be a mix design tool. Rather, it will provide guidance on levels of SCMs that could be used in a given project.)
3. Calculate the carbon savings resulting from the use of supplementary cementing materials, and other potential environmental benefits (such as a reduction in other air contaminants).
4. Calculate the cost benefits/disadvantages of using SCM.
5. Provide recommendations and guidance for the end users.

Knowledge Base/Data Base

The knowledge base/database section of the SOS contains various databases to be assembled for this project, including but not limited to the following:

1. Codes and Standards: a collection of relevant requirements and specifications found in construction codes and standards, such as CSA, ACI, LEED, etc.
2. Performance data: a collection of empirical test data from literature and case studies.
3. Material Properties database: information collected from literature on the various types of SCM including relevant links to the Codes and Standards database described in 1. above.
4. Climate database: a collection of regional climatic data, which can be drawn upon to determine the effects of SCM usage during construction.
5. Material Availability and Cost database: market information collected to provide users with information on which SCM is most useful to their project from a purely material cost standpoint.
6. Good Practice database: a collection of information from case studies and literature to aid users in the use of SCMs.

These databases are used to provide users with a range of possibilities available for SCM optimization.

Summary

The SOS (SCM Optimization System) is an expert system and decision-support tool designed to help the construction industry optimize the use of SCM in concrete according to four main criteria: Cost, performance, constructability, and GHG reduction. It will contain the state-of-the-art knowledge on concrete technology and practices. It will support the cement and concrete industry efforts to address the challenges of a carbon-constraint future.

Extension of the SOS project to China

The SOS will provide an enabling environment for the development, diffusion, deployment, and transfer of a cost-effective, cleaner, and more efficient alternative to cement. It is based on an existing technology, complements current efforts of the cement industry, and engages construction industry main stakeholders, research institutions, governmental, and non-governmental organizations.

Canada, which has emerged as a world-leader in the use of High Volume SCM concrete, is prepared to share its experience and knowledge and exchange information with China in an effort to support the common goal of developing and implementing clean development strategies and efforts to reduce greenhouse gas emissions.

This initiative that allows reducing the overall GHG intensity of cementing material by addressing practical barriers contributes to China's GHG reduction general objectives. Concrete technology is universal and the SOS software could be used in China. However, differences in language, codes and standards, material, or construction practices will require adapting the software to local conditions.

China is the largest producer of cement as well as the largest producer of SCM in the world (both fly ash and slag); increase of use of SCM in concrete will thus produce a considerable GHG reduction. Canada is a leader in HVSCM technology. While the tool currently developed is designed to facilitate adoption by the Canadian construction industry of concrete with lower GHG footprint, it could have a much higher leverage in China where GHG emissions from cement making are about 100 times bigger than in Canada. Collaboration between Canada and China under the auspices of APP would bring an enormous leverage.

The software is currently developed by SIMCO, well-known concrete, material and professional software experts based in Quebec, Canada. The first step of implementing the program in China is to engage key stakeholders of the local industry, including all the disciplines and sectors that are typically involved in concrete construction project such as cement producers, SCM suppliers, concrete manufacturers, engineers, contractors, academics, research institute and building codes officials. The APP project will progressively introduce the concept to the Chinese industry through a series of meetings and communications with the objective of creating a Chinese group interested to further the application of the concept to China.

1. Approach and consult selected organizations related to the Chinese construction industry (officials, engineers, producers, contractors and academics) through a series of workshops and one-to-one meetings to determine requirements, scope and interests.
2. Collaborate with these organizations to identify existing knowledge and information needed to support increased use of SCM in China such as SCM use, cement properties, climatic data, codes of practice, standards, building codes, environmental regulations, etc.
3. Identify compatibility requirements between the Canadian program and the Chinese context by getting feedback from these organizations.
4. Collaborate with these organizations to identify and facilitate methodologies and channels to access and collect the data, including QA/QC procedures to ensure data accuracy and reliability.