Preparation of a Performance-Based Specification for Cast-in-Place Concrete

Summary of Proposal[1] Submitted by

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Statement of Purpose

Historically, most specifications have been mainly prescriptive in nature. It has long been realized that this limits the ability of the contractor and concrete supplier to exercise their particular skills and knowledge, as well as limiting their ability to take advantage of economically available materials.

In 1964 in a thesis for completion of the requirements for Associate Membership of the Institution of Civil Engineers Bickley stated that, "In principle a specification should state the minimum essential properties of the hardened concrete. The Contractor should then be given as much scope as possible as to how he obtains these properties, subject to satisfying an initial approval procedure to ensure that what he is proposing does meet specification requirements. The specification should also make clear what inspection and control standards will be applied." This statement was prepared in reaction to experience gained while dealing with prescriptive specifications on 16 Atomic Energy contracts containing conflicting and unworkable clauses.

In 1991 Bickley participated in the development of a long range research plan, written for the Ontario Ministry of Transportation (MTO). In that plan it was noted that in 1990 the *FHWA Steering Committee on Research and Development Needs in Highway Construction* had made Performance Specifications their number one priority. A budget of $27,000,000 and 180 man-years was suggested.

Also in 1991 a meeting was held at NIST to formulate a research plan for the USA in the area of high performance concrete. A summary of conclusions reached was:

1. Progress can only occur if innovation is allowed, and the contractor can exercise to the full his expertise and that of his suppliers.
2. Such progress can only result from the use of performance specifications that place full and clear responsibility on the contractor.
3. Test procedures are needed so that the owner can determine very early in the life of a structure that the performance of the concrete will meet specific requirements.

In the 1991 research plan for MTO it was noted that an analysis of compression test results from end-result and traditional prescriptive specifications showed that the former produced a higher level of quality control by the contractor.

The long-term, gradual increase in performance oriented requirements in Canadian specifications will be reflected significantly in the next edition of CSA A23.1, *Concrete Materials and Methods of Concrete Construction*, due in December 2004.

In May 2001 the Cement Association of Canada published *"A State-of-the-Art Review of High Performance Concrete Structures Built in Canada: 1990-2000"*. This showed that across the country many agencies had adopted some performance requirements in their specifications.

Several US State Departments of Transportation, with the support and encouragement of the Federal Highway Administration have made important strides towards concrete performance specifications. From 1999 to 2002 Hover developed The FHWA course on PCC Mixture Proportioning, which was designed to facilitate the transition to performance-based specifications and contractor mix-design. This course begins with a group exercise asking the students to develop a list of performance-based concrete characteristics for fresh concrete, hardened concrete, and for the transition between the two. This is to expand participant's thinking beyond the traditional DOT "recipe" specifications, and to demonstrate the benefits of turning mix proportioning over to producer-contractor. The course then goes on to provide training for concrete producers and contractors.

The above comments may be preaching to the converted, and other examples of the trend to performance specifications could be cited, but the trend towards performance-based specifications is clear and momentum is building to increase the performance related content of specifications.

The goals of this proposal are:

1. Production of a model specification as performance-oriented as possible, given the present state-of-the-art and current limits of technology, and
2. Identification of the steps needed to be taken in the development of rapid and reliable means of confirming specified performance.

The successful completion of this project will provide the ready mixed concrete industry with a credible tool that can be used to educate clients and promote the use of performance specifications.

Methodology

The project will be separated into two phases[2]:

1. A literature review of current practice to produce performance concrete codes and specifications by others in the USA, Canada and other countries, including surveying test methods in use and under development that can be used to confirm performance. This would include identification of problems and proposed resolutions, where possible.
2. Develop specific code and specification change submittals that can be forwarded to ACI Committees 301 and 318, then draft and prepare for publication a model performance-based specification in modular form.

The draft specification would be compatible with the language and format of ACI 301 and ACI 318.

Under Phase 1, existing performance-oriented models such as the draft CSA A23.1 standard will be examined for suitability. This CSA standard contains exposure classes for the various concrete durability concerns (e.g. Chloride, seawater, freeze/thaw, and sulphate exposures) as well as a guide for dealing with alkali-reactive aggregates, and outlines specific concrete requirements in each case. Many of these requirements are performance based, with the obvious exception of w/cm limits. In addition, it is proposed to include a low-shrinkage option using shrinkage limits for use with ASTM C 157 testing (or with other applicable test methods).

Other standards such as EN206-1 will also be considered, either in whole or in part. Current end-result specifications for concrete, such as those used by the Departments of Transportation in Virginia, Iowa, Minnesota and Ontario, will also be examined. As a follow-up to the recent Anna Maria, Florida workshops, Hooton has recently been involved with developing a summary of available standard test methods for various performance issues, as well as identifying their weaknesses and limitations. One of the conclusions in this paper states, "It is now time for us to move to a much more extensive use of performance-based specifications. If these can be properly devised, they would encourage concrete producers to be more imaginative and innovative in their use of materials, such as supplementary cementing materials, admixtures, blended cements, polymers, fibers, mineral fillers, etc. They would also provide a means for introducing durability concerns more explicitly into the design of concrete mixtures".

Available search engines and the personal contacts and libraries of the project team would be used to assemble the relevant information available. This information would then be synthesised to determine the current state-of-the-art.

Deliverable Product and Dissemination Plan

The deliverables will include:
Phase 1

1) The Phase 1 report on the Current State of Practice with performance-based specifications.

Phase 2

2) Development of specific code change submittals for consideration by ACI 318.
3) Produce a Model Guide Specification with Commentary in format suitable for use by the design community.
4) Make recommendations as to suitability of existing test methods for use in the model specification and to suggest areas of needed research.

Application in Association Community

It is expected that the ultimate results of the work will lead to a broadly applicable approach to performance-based specifications that can be used across the ready-mixed concrete industry. A goal of a model specification is to allow for locally specific modification as required.

Evaluation

Initial evaluation will be performed by the sponsor upon receipt of the draft report. Subsequent evaluation and adoption by code- and specification-writing agencies is excluded from the scope of this work.

Qualifications

Professor Ken Hover started his career in military construction and as an engineer with Dugan & Meyers Construction in Cincinnati. Project engineer and project manager assignments included the I-471 Bridges over the Ohio River and several treatment plants. He subsequently joined THP Structural Engineers as a designer, specifications writer, contract administrator, partner, and manger. Staying at Cornell University after earning the Ph.D. in 1984, Ken teaches reinforced concrete design, concrete materials and construction, and construction management. Ken is an ACI Fellow and recently completed his term as a member of the ACI Board of Directors. He serves on several ACI committees including the 318 Building Code Committee. Ken develops and presents training courses for many industrial organizations, State Departments of Transportation, and the Federal Highway Administration. He has been the top rated technical speaker at World of Concrete each year since 1995.

Professor Doug Hooton has been working since 1986 at the University of Toronto and before that at Ontario Hydro conducting research on new and modified test methods for concrete properties, especially those for permeability and durability. He currently serves on 39 code and standards committees of ACI, ASTM, TRB, CSA, and RILEM. He is a member of ACI 318A, former Chair of ASTM Committee C09, current Chair of ASTM C09.66 on Resistance to Fluid Penetration, and was Chair of CSA A3000 for most of the recent amalgamation of all the cementitious materials standards into one document. He has received the Award of Merit from both ASTM and CSA.

Mr. John Bickley has spent 51 years in the construction industry and has worked in 14 countries. He has extensive experience of enforcing specifications written by others and also writing specifications himself. For over 35 years he has served on Canadian, US and overseas committees, and has chaired a number of these, including ACI 228 and ACI 363. He has received awards for his committee work.

Ken Hover will head the project, acting as an independent consultant. The services of Professor Hooton and Mr. Bickley will be provided through MDC Inc. MDC is a company owned by 10 engineers who were previously Principal Investigators with Concrete Canada and was incorporated after government funding of Concrete Canada came to an end.

SCHEDULE

DELIVERABLE	DESCRIPTION	DELIVERY DATE
List of Reference Materials	A list of reference materials collected as a result of the literature search	January 31, 2005
PowerPoint Presentation (including delivery to P2P Steering Committee by Ken Hover)	A PowerPoint Presentation describing the findings of the literature search and preliminary assessment of current codes and specifications from around the world.	March 3, 2005
Proposal for Phase 2 of the research.	A proposal for Phase 2 of the research as described in the Proposal for Phase 1	March 31, 2005
DRAFT Final Report	DRAFT Final report describing the findings of the literature search and assessment of current codes and specifications	April 30, 2005
Technical Paper	Technical Paper ready for publication in an industry journal summarizing research findings	May 31, 2005
Final Report (final revisions)	Final report as described above including revisions as suggested by Ready Mixed Concrete Research Foundation.	May 31, 2005

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Notes

1. This document is a summary of a proposal submitted to the Ready Mixed Concrete Research Foundation for research funding. The summary should be used for information purposes only. Many of the details including cost, schedule, and detailed qualifications of the researchers have been removed.
2. This proposal describes work to be completed in Phase 1 of a two-phased project. A detailed proposal for Phase 2 will be developed as part of the Phase 1 work.