The P2P Initiative

A Shift to Performance Specifications for Concrete Focuses on Innovation, Quality and Customer Satisfaction

Since the early days of the ready mixed concrete industry in the 1920s, technological advances, production capabilities and practices of concrete producers have evolved into an advanced science. Most modern ready mixed concrete production facilities have laboratories that incorporate rigorous quality control and product development programs, and expert concrete technologists to develop innovative concrete mixtures for any application—from houses to high-rises and sidewalks to superhighways. Unfortunately, typical project specifications are prescriptive in nature and stifle innovation by limiting the types and quantities of ingredients and material proportions. Prescriptive specifications are often overly conservative which can lead to higher costs and unexpected negative results, ultimately leading to unsatisfied customers. The concrete producer should be part of the team that delivers a quality constructed project since he is the expert on the material he manufactures and delivers. The same goes for the progressive contractor.

A shift to performance-based specifications is the next logical step in the evolution of the ready mixed concrete industry. Performance-based specifications provide details of required results such as strength and other mechanical properties along with requirements for durability and ser-

Figure 1. Performance-based specifications foster innovation and acceptance of new technology such as high-strength concrete and self-consolidating concrete for high-rise construction.

viceability. The results are verifiable through measurement or testing to assure the product meets the desired requirements. And finally, performance-based specifications are free of process limitations such as mixture proportions and construction methods. Performance-based specifications encourage innovative products and construction methods along with rigorous quality management systems that lead to superior products and satisfied customers.

The ready mixed concrete industry recognizes customer needs will best be served through innovative concrete technology and improved quality—the outcomes of performance-based specifications. Led by the National Ready Mixed Concrete Association (NRMCA), the ready mixed concrete industry has established the P2P Initiative to promote a shift from traditional prescriptive specifications to performance specifications for concrete. P2P is an acronym for Prescription to Performance specifications.

The Research, Engineering and Standards (RES) Committee of NRMCA formed the P2P Steering Committee in October 2002 to develop a strategic roadmap for the P2P Initiative. The Steering Committee has collaborated with industry stakeholders including concrete contractors, material suppliers, engineers and architects to develop a set of goals and strategies to implement performance-based specifications.

The primary goal of the P2P Initiative is to improve the quality and competitive position of concrete by moving away from prescriptive requirements to those based on performance criteria. All stakeholders in the construction process must see a benefit to themselves. There is no intent to eliminate prescriptive specifications. These traditional modes of specifying concrete can work well in certain market areas and in certain established relationships. One effect could be that there will be an improvement in prescriptive specifications whereby some of the inherent conflicts are eliminated and responsibilities are more clearly defined.

Strategies for the P2P initiative include:

- Promote performance specifications as an alternative to current prescriptive specifications through education and communication
- Leverage the expertise of all stakeholders in the construction industry to improve quality and reliability of concrete construction
- Assist architects and engineers to address concrete specifications in terms of performance requirements, allowing concrete suppliers and contractors flexibility on the details of concrete mixtures and construction means and methods
- Elevate the performance level and credibility of the ready mixed concrete industry through training and certification
- Foster innovation and acceptance of new technology at a faster pace through research and development

P2P shifts the emphasis from prescribing the ingredients and their proportions in a concrete mixture to an emphasis on the performance properties of the combined materials. The details of a concrete mixture for the most part have little meaning to a contractor, design engineer or owner of a building or roadway. Concrete producers, on the other hand, have to maintain an expertise that allows them to optimize the mix for predictable performance, both in its plastic and hardened state. They have to know their ingredient materials and should be competent in mixture proportioning to compete and deliver a long-lasting product in a competitive environment. The P2P Initiative is a large undertaking with far-reaching implications throughout the construction industry that will require coordination with, and support from, project owners, government agencies, codes and standards organizations, engineers and architects, contractors and concrete producers. Eventually it should be considered an industry initiative rather than that of one group.

For the most part, state departments of transportation [DOT] employ prescriptive specifications for concrete. Some state DOTs have experi-

Figure 2. The P2P Initiative of NRMCA promotes a shift to performance-based specifications for concrete construction that includes highways and local roads.

mented with performance-based specifications on high-performance concrete especially for bridge applications where durability and long life are critical. These applications are at the cutting edge of concrete technology, using a wide range of supplementary cementing materials and admixtures along with innovative construction techniques to minimize permeability and cracking. The intent is to extend the life of structures beyond 100 years—which is significant in light of the harsh environments in which these structures reside. The NRMCA P2P Steering Committee has invited federal and state DOT engineers to draw on their experience with performance specifications to develop guide specifications.

The NRMCA P2P Steering Committee is coordinating projects through the RMC Research Foundation to develop a guide performance specification and propose changes to building codes and standards to better address performance specifications. Researchers will perform a review of existing literature to identify where prescriptive requirements are built into the codes and reflected in specifications for concrete and propose new language to replace pertinent sections of ACI 318 and ACI 301. Researchers will identify performance objectives for concrete including pre-qualification and acceptance tests. Researchers will review existing performance-based standards from around the world including Canada, Europe and the U.S.

The guide specification will allow designers to prepare concrete project specifications and contract documents that outline the performance requirements, submittal requirements, prequalification requirements and acceptance criteria. The guide specification will identify consequences of non-performance and a resolution mechanism. In addition to design requirements, the guide will include a mechanism whereby contractors can add construction requirements for installation and delivery. Producers would then be able to use designer and contractor requirements to submit a bid showing levels of performance, cost, delivery rate, prequalification test results and plant certifications.

For some performance criteria, practical prequalification or field acceptance tests do not currently exist. Tests that are expensive or take excessive time to conduct are not practical for construction. The NRMCA P2P Steering Committee intends to conduct research to identify appropriate tests and, if required, develop new tests for use in performance specifications.

Specifiers, contractors and producers must be educated on the benefits and proper use of performance specifications. The NRMCA P2P Steering Committee plans on educating producers, contractors and specifiers through seminars and

distribution of guide specifications. In addition, NRMCA staff and members are working with national and local groups such as the American Concrete Institute (ACI), the American Society of Civil Engineers (ASCE), and the American Institute of Architects (AIA) to communicate the benefits and proper use of performance specifications.

The P2P Steering Committee also intends to conduct a laboratory study designed to demonstrate the advantages of performance-based specifications over prescriptive specifications for concrete. Concrete specimens will be prepared using typical prescriptive specifications such as those in ACI 318 and tested for a variety of attributes including strength, scaling, sulfate resistance, corrosion and permeability. The results will be compared to specimens prepared using performance-based specifications. Both fresh and hardened concrete properties will be quantified and compared.

What is a Prescriptive Specification?

A prescriptive specification is one that includes clauses for means and methods of construction and composition of the concrete mix rather than defining performance requirements. Many times intended performance requirements are not clearly indicated in project specifications and the prescriptive requirements may conflict with the intended performance.

The producer is always called on when the mix does not perform even though this is in conflict with the basic premise of a prescriptive specification as clearly indicated in ASTM C 94, *Specification for Ready Mixed Concrete*. For example, a low water-cementitious materials (w/cm) ratio at high paste content might increase the potential for shrinkage and cause more curling in a concrete floor while the intent was to reduce it. This might also cause a stiff mix that will adversely affect placing and finishing.

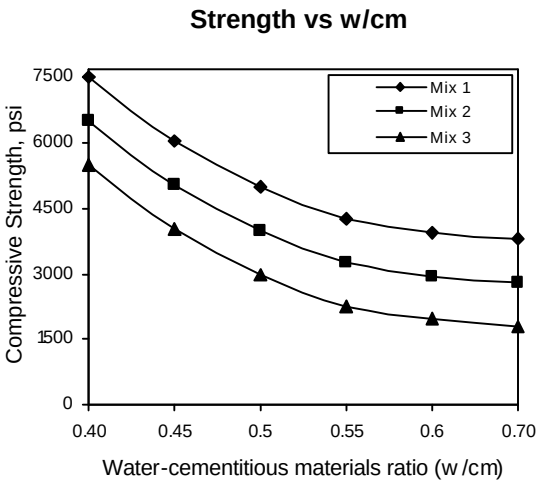

Figure 3. Specifying a w/cm ratio does not ensure specified strength will be achieved. A 0.45 w/cm ratio for the three mixes in the graph above have strengths of 3,800, 5,000 and 6,000 psi respectively.

Many project specifications include prescriptive limits on w/cm ratio as a surrogate for durability. The intent is to reduce permeability of the concrete. There are many ways to achieve this with the use of supplementary cementing materials and admixtures. The typical process of working with a w/cm limit is to start with water content as required for a target slump and the local aggregates. The cement content is then calculated. Conforming to a low w/cm ratio generally drives the cement content higher which leads to higher costs. Alternatively, admixtures can be used to reduce the paste content in the mix.

For each set of materials there is a unique relationship between the strength and w/cm ratio. A different set of materials has a different relationship as illustrated by the plots of compressive strength versus w/cm ratio for the three different mixes as shown in Figure 3. A 0.45 w/cm ratio for these three mixtures have strengths of 3,800, 5,000 and 6,000 psi respectively. Clearly specifying a w/cm ratio requirement does not ensure certain strength will be achieved.

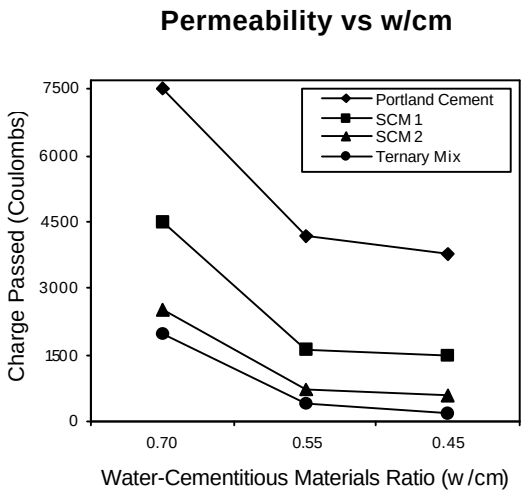

Figure 4. Specifying a w/cm ratio does not ensure low permeability. At 0.45 w/cm ratio, the four different mixes shown above have very different permeability.

For the most part, maximum w/cm ratio is included in prescriptive specification to ensure durability, which is generally affected by the permeability of concrete. Generally, as w/cm ratio decreases, an electrical charge passed through hardened concrete (a measure of permeability) decreases. Alternatively, cementitious components of the mix can also be varied to decrease permeability. Different combinations of portland cement and supplementary cementitious materials (SCM) such as fly-ash, slag, silica fume and other pozzolans can drastically affect permeability.

For example, the four different mixes shown in Figure 4 have different permeability at the same w/cm ratio ranging from very low permeability for the ternary mix (portland cement plus two SCMs) to very high permeability for the portland cement only mix. Even though a producer furnishes a mix at 0.45 w/cm ratio, there is no guarantee that the mix will have low permeability.

This is not to say that w/cm ratio is not important. It is a parameter concrete producers use to design concrete mixtures. It should not however be a specification requirement. Furthermore, w/cm ratio cannot be measured or enforced on the jobsite by a reliable test and a specification requirement that cannot be enforced is not effective.

Prescriptive specifications also lead to higher costs. The bidder with the lowest overhead—which usually means lowest investment in quality control, research and development—is often the one that can bid the lowest and profit the most at the lowest bid. An engineer might think he has established a level playing field with a prescriptive mix, but in fact he is encouraging low quality. For this reason, engineers often revert to more prescriptive specifications that are extremely conservative (over-designed) to compensate for low quality leading to higher costs. If the engineer specifies the desired performance and relies on the expertise of the concrete contractor and concrete producer to deliver an optimized mix, it can often be delivered at lower cost and higher quality.

What is a Performance Specification?

A performance specification is a set of instructions that outlines the functional requirements for hardened concrete depending on the application. The instructions should be clear, achievable, measurable and enforceable. For example, the performance criteria for interior columns in a building might be compressive strength and weight since durability is not a concern. Conversely, performance criteria for a bridge deck might include strength, permeability, scaling, cracking and other criteria related to durability since the concrete will be subjected to a harsh environment.

Performance specifications should also clearly specify the test methods and the acceptance criteria that will be used to verify and enforce the requirements. Some testing may be required for pre-qualification and some might be for jobsite acceptance. The specifications should provide

flexibility to the contractor and producer to provide a mix that meets the performance criteria in the way they choose. The contractor and producer will also work together to develop a mix design for the plastic concrete that meets additional requirement for placing and finishing such as flow and set time while ensuring that the performance requirements for the hardened concrete are not compromised.

Performance specifications should avoid requirements for means and methods and should avoid limitations on the ingredients or proportions of the concrete mixture.

The general concept of how a performance-based specification for concrete would work is as follows:

- There would be a qualification/certification system that establishes the requirements for a quality control management system, qualification of personnel and requirements for concrete production facilities.
- The specification would have provisions that clearly define the functional requirements of the hardened concrete.
- Producers and contractors will partner to ensure that the right mix is developed, delivered and installed.
- The submittal would not be a detailed list of mixture ingredients but rather a certification that the mix will meet the specification requirements including pre-qualification test results.
- After the concrete is placed, a series of field acceptance tests would be conducted to determine if the concrete meets the performance criteria.
- A clear set of instructions outlining what happens when concrete does not conform with the performance criteria.

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