Specifications and Submittals—

Is a Change in Order?

BY COLIN LOBO

Are bakers who supply the cake for a wedding told how to prepare the cake, and required to list the type and amounts of all ingredients used in preparing it? Most bakers would balk at such a requirement. They could argue quite convincingly, I believe, that they know more about preparing a cake than their customer does, and that the type and amounts of ingredients are a well-kept secret, perhaps passed down through many generations.

The analogy to concrete production isn't a perfect one, but there are certainly some similarities. Construction specifications usually tell ready-mixed concrete producers how to make concrete and require them to submit concrete mixture proportions and material characteristics. While there has been some progress in moving toward performance specifications for concrete, most specifications today still have prescriptive provisions that specify the types and quantities of the mixture ingredients, limit the amounts of cementitious materials, and specify maximum water-cement ratios and aggregate grading limits. Often, the specification combines prescriptive and performance criteria that are in conflict, for example, a "3000-psi" mixture at a 0.40 water-cement ratio.

THE DOWNSIDE OF PRESCRIPTIVE SPECIFICATIONS

Prescriptive specifications inhibit innovation and professionalism in the concrete industry. They also limit the competitiveness, profitability, economy, and assignment of responsibility for concrete construction. The ready-mixed concrete producer is intimately familiar with the product and its ingredients and should be responsible for proportioning and modifying the mixture to meet the customers' performance requirements. Most ready-mixed concrete producers have laboratories, qualified technical personnel, and registered professional engineers on staff to proportion ingredients and maintain concrete uniformity and predictability. If all potential bidders are required to use a cement factor of 500 lb/yd^3 (300 kg/m^3), the one that has the advantage for highest profit at the lowest bid is one that does not have the necessary investment or overhead for a quality management system and this may not be in the best interest of the purchaser.

The design professional is qualified to design the structure and should indicate the performance requirements that are appropriate to the constructed structure in terms of performance test criteria. The contractor has certain constructibility criteria that need to be considered in the specification. Neither, however, may be qualified to proportion a concrete mixture or discern what is relevant in a submittal that details the mixture composition. Concrete producers on the other hand, *must* be competent in mixture proportioning for economy and increased profitability if they are to survive in today's competitive environment.

Admittedly, we do lack reliable tests and criteria for certain performance attributes, which makes us default to prescriptive limits. The research community should (and has) help(ed) in eliminating prescriptive provisions that intend to control durability characteristics. Examination of the requirements in Chapter 4 of ACI 318-02, "Building Code Requirements for Structural Concrete," would be a good start. Does a water-cement ratio limit in a specification really mean anything? At a 0.40 water-cementitious materials ratio (w/cm),

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concrete mixtures with different ingredient materials can have a wide range of permeability. Besides, a *w/cm* requirement is not enforceable on the job site with a reliable acceptance test.

The ready-mixed concrete industry in the U.S. has progressed to a highly professional industry from its roots in the 1930s when it primarily "trucked" material. The industry manufactures a very versatile product in a volume exceeding 400 million cubic yards (300 million cubic meters) annually. Ready-mixed concrete can be customized for a variety of applications from very low strength to extremely high strength and enhanced durability; and to accommodate a significant range of placement procedures that enhances the productivity of its contractor customers. Batch modifications are necessary and possible in real time to accommodate variations in the ever-increasing number of ingredient materials, environmental conditions, placement methods, and customers needs. Such modifications may not be allowed, however, because specifications for ready-mixed concrete have not evolved in concert with the expertise of the industry and product innovations.

PROPRIETARY CONCERNS

Submittals are an ingrained process of a construction project. Mixture submittals for concrete generally require details on the mixture ingredients and quantities—details that should be considered proprietary knowledge of the concrete producer, especially for special mixtures or job requirements. Sometimes a purchaser will "shop around" mixture proportions to find a lower bidder, which is a misuse of the submittal process. In any case, concrete producers lose a competitive advantage when they must disclose the type and amounts of materials used to produce the plastic—and hardened—concrete properties required by the specifications.

HOW DO WE MOVE FORWARD?

The details of a concrete mixture have no consequence to the contractor or the design professional, other than possibly providing a feeling of comfort. The concrete should perform as expected during placement and after it has hardened, regardless of what is in the mixture. If acceptance test results indicate that the concrete failed to meet specification performance requirements, the submittal has no relevance.

Because the current system has been in place for many years, however, changing it will be difficult. The credibility level of the ready-mixed concrete producer, and trust on the part of the purchaser, will be major drivers in any effort to affect changes in the specification and submittal process. Some of the following suggestions might help move from prescriptive towards performance-based specifications:

- Facilitate the development and use of performance-based test methods and criteria, specifically for durability, that eliminate prescriptive provisions in specifications;
- Revise the submittal process currently required in documents such as ACI 301-99, "Specifications for Structural Concrete." A generic submittal form should reflect the specification requirements and an indication that the concrete furnished will meet the requirements. If necessary, a professional engineer could certify the job mixtures;
- Eliminate the inclusion of the historical record of strength test results in the submittal. The producer should be able to choose a level of risk on factors such as the strength level, plant reliability, time of year, and even, who is employed to do the acceptance testing;
- If submittals of mixture proportions are required, the engineer should approve them prior to commencement of the work and share in any liability for nonperformance of the product;
- The concrete producer should bear no liability for product performance when batch records indicate conformance with the prescriptive provisions of a specification; and
- To establish their credibility, ready-mixed concrete producers could agree to subscribe to a quality management system. The system would include a quality control plan that outlines tests and management of ingredient materials, qualification of personnel, certification of plants, and use of an accredited laboratory (owned or contracted with by the producer) to develop mixture proportions and for product quality control.

As more concrete producers position themselves to be *gourmet chefs* in control of their product and thereby their profitability, they must concurrently establish the credibility needed to ensure the purchasers' trust. It's this author's point of view that members of the concrete industry should be empowered to produce products, based on their knowledge and experience, that will meet the customers' performance requirements.

Selected for reader interest by the editors.

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Response to Colin Lobo's November 2002 article "Specifications and Submittals ? Is a Change in Order?".

Tim Hickisch, P.E. Denver, Colorado

I read Mr. Lobo's article with much interest since a recent concrete mix submittal on one of our projects specifically did not include mix proportions. When we contacted the supplier, this national ready mix company asked for a signed confidentiality agreement before the mix proportions were released. We were surprised and a bit perplexed.

I agree that his baker's analogy is not a perfect one. Another imperfect analogy may be selecting a new suit only by its fit and color. All blue, 43 regular suits are not the same. It's in their make up that defines their quality. And so it is with concrete.

Quality concrete is not only measured by its minimum strength in 28 days. Everyone that reads this magazine should know that. Durability and permeability are only two attributes that are major concerns. Include shrinkage, placeability, sulfate resistance, among others and you have matrix of concerns the design team, as a whole, needs to content with.

Some of our recent projects have included concrete drilled piers where the slump of the concrete delivered to the site was well below the required 7". When I contacted the concrete supplier, they seem to say "but look at the strength! The project required only 3000 psi and you've got 4000 psi! What's the problem?" Suppliers have become so focused on strength that they cannot even imagine the structural implications of rock pockets or voids at the base of a 50' long pier supporting 900 kips.

That brings up another point regarding conflicting performance criteria. I will sometime specify some criteria that seem to be in conflict. but they really are not if you look at them as limits, minimums and maximums only. This is especially relevant to drilled piers. While concrete strength may not govern the pier design, sulfate resistance may require a low w/cm for permeability. So I might specify a 3000 psi mix with a 0.45 w/cm. An option would be to arbitrarily raise the required strength to 5000 psi to more closely match the w/cm requirement. This does two things: it excludes the ready mix producer that has a 4500 psi mix that meets the 0.45 w/cm; it also lessens my credibility if, by chance, the test results indicate some of the concrete only reached 4000 psi. Then I have to say "that's ok, we only needed 3000 psi."

By specifying the actual requirements, the ready mix supplier should have the most flexibility to tailor a mix to meet the needs of the project. I believe the problem with seemingly conflicting criteria is with communication between the ready mix supplier and his client. If the client asks for pricing for a 3000 psi mix, the ready mix supplier should be knowledgeable enough to know that strength is not the only governing criteria and ask for a complete listing of required criteria.

We use a matrix to specify our concrete requirements like w/cm, minimum cement content, % air entrainment, etc. While Dr. Lobo suggests this limits ready mix producers, I believe it provides an even playing field for all bidders.

Dr. Lobo recommends eliminating historical records for strength testing. I believe these histories provide a real means to verify the proposed mix will meet the project specifications. Many times I've reviewed test histories only to find that what was proposed as a 3000 psi, 5" + 1" slump with 6% + 1% air entrained mix is actually a 3500 psi, 4" + 1½" slump with 4% + 1% air entrained mix. In this case, I will not approve a mix that might have a 2-1/2" slump and only 3% air entrainment. The supplier's response is usually to note that it exceeds the required strength.

Dr. Lobo suggests that engineers should share liability with the ready mix supplier for nonperformance when mix proportions are required. While some required mix proportions may not provide the most economical way to a desired mix, they rarely, in my experience, resulted in nonperformance.

I agree with Dr. Lobo that we lack reliable tests and criteria for these performance attributes. So develop these tests and criteria first. Almost all of his suggestions to move towards a more performance based specifications hinge on these being developed. Without them, the rest of his reform is not viable. His main call should be to his constituents to do this, not to ask the design community to change what has been a successful method of concrete selection.

Finally, Dr. Lobo's comment that the "details of a concrete mixture have no consequence to the contractor or the design professional, other than possibly providing a feeling of comfort" is indicative of a person that has never been responsible for the design of a concrete building. While design has gotten more precise, the quality of concrete construction has diminished in my opinion. The design professional desires not comfort but a reasonable assurance that the final in-place concrete structure has the capacity required to provide a safe and long-lasting building.

Lobo Response to Hickisch

I thank Mr. Hickisch for his comments to the Point of View article in CI, November 2002. His response reinforces the current paradigm of concrete construction whereby there are at least three independent parties - the architect/engineer, the contractor and the material supplier –focusing on their own responsibilities rather than partnering towards a successful project.

I agree with Mr. Hickisch that quality concrete is not solely measured by its minimum strength as that was the point of my article. That is the sole performance criteria called for in most concrete specifications, so it is no wonder that the producer is focused on strength because that is the basis by which he is judged and paid. Clearly there are constructability and durability requirements that Mr. Hickisch lists and the challenge to the engineer is to incorporate these requirements in the specification as performance-based criteria that can be measured by reliable test methods. As always, if the concrete delivered does not meet performance-based specification requirements, it can be rejected or penalties applied as defined in contract documents. Since specifications are seldom read in detail it benefits the involved parties to participate in pre-construction, or even pre-bid meetings on any significant project. The concrete producer will then appreciate why Mr. Hickisch needs the 7-inch slump for the drilled piers and alternative options can be defined when this slump is not achieved at the jobsite.

Mr. Hickisch’s arguments regarding conflicting performance criteria, the 3000-psi with a 0.45 w/cm ratio, needs some comment. Like the design engineer, the concrete producer should be designing concrete mixtures for the most critical criteria (see ACI 211.1). The w/cm ratio is specified to achieve a degree of permeability. Why not specify a permeability criterion? (I understand here that he is restricted to some extent by the Code). There are many specifications that do so and some in Canada that have gone beyond that to specify a diffusion coefficient. The presumption by the design engineer is that there is a universal relationship between w/cm ratio and permeability or sulfate resistance or even strength. This might have been marginally true with mixtures containing only portland cement. With the variety of options available to design concrete mixtures today, however, there are several innovative and optimized methods to achieve the desired permeability and the required strength without being constrained by a w/cm ratio requirement. Since the water requirement is essentially controlled by the local materials and admixtures used, conforming to a w/cm ratio requirement causes an increase in the content of cementitious materials to possibly result in side effects such as increased cracking, shrinkage, creep and other detrimental effects. Also, compliance with the w/cm ratio is not really verified other than in the mixture proportions on paper

in a submittal. Lastly, the conflicting requirements are likely to get someone in trouble because the order did not include the w/cm ratio or it was bid on 3000-psi or for some other reason due to lack of communication. This type of specification sustains the mindset that concrete is a commodity and stifles innovation and value to the project. Hopefully, this is what specifying engineers most want to avoid.

Mr. Hickisch indicates that the ready mixed supplier has the most flexibility to tailor a mix when *actual* requirements are specified. I am not sure what he means by actual requirements but there is clearly no flexibility when the specification is limiting in a prescriptive manner. He provides a level playing field with a prescriptive specification matrix and I implied in the article that this is clearly not to the benefit of the purchaser as there is no incentive at all for even basic quality control as that is a cost item that takes away from the producer's profitability. To get to research and innovation will require risk and definition of performance characteristics in specifications.

In my article, I did not recommend eliminating historical strength records. I think this is valuable information that defines the variability of concrete from a specific production facility and it establishes a producer's overdesign to meet the specification. I do not see the value of this record in the submittal. A standard deviation for different classes of concrete would suffice and if the historical job was marginally different from the proposed job, it does not really matter because the acceptance criteria on the job govern in any event. The point is that the producer is constrained from choosing his level of risk based on a historical record that might not be pertinent to the proposed work and documenting these records is quite onerous in a job submittal for no real benefit.

Mr. Hickisch indicates uneconomical prescriptive mixes rarely result in non-performance. I think the industry can cite numerous examples where prescriptive limits on w/cm ratio, aggregate content, minimum cement factors, or the inability to make real time deviations from a submitted mix have resulted in concrete that could not be placed or pumped, did not set up in time, had excessive cracking or otherwise did not achieve the desired performance properties. And the liability typically falls on the concrete producer and not the engineer who essentially controlled the mix design. I agree with Mr. Hickisch that I have not been responsible for the design of a concrete building and for that reason I do not comment or make recommendations on building design issues as my background and qualifications are not in that area of expertise.

Mr. Hickisch asks me to call on the ready mixed concrete industry to develop reliable tests and criteria for performance specifications. This is a good chicken and egg argument as performance standards will not progress if specifications do not use them and with the current level of partnership, they definitely will not be used if proposed by a supplier. The design engineer is either unaware of developments or too conservative to change what Mr. Hickisch claims to be a successful method of concrete selection. Later on, though, he claims that the level of quality concrete construction has diminished. There are numerous examples of improved concrete mixture technology and construction equipment and processes (just like improved precision in design) that have not *made it* because our standards take a long time to recognize them and the specifications have not changed to benefit from them.

I need to clarify that the case cited where a producer asked for a confidentiality agreement is most likely that company's policy and not the result of a collaborative effort of concrete producers through NRMCA where any such effort will be purely voluntary.

Colin Lobo