Impact of Project Specifications on Sustainable Development

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The ready mixed concrete industry has been proactive in recognizing the challenges and opportunities resulting with the trend toward sustainable development in construction. NRMCA Sustainability Initiatives, endorsed by the membership, establish goals for reducing the overall environmental footprint of concrete materials and production and establish strategies and credits for achieving these goals. Specifically, the goals include minimizing energy use, reducing CO_2 footprint of concrete, reducing potable water use, reducing waste and increasing the use of recycled content. Other initiatives supported by the NRMCA membership include the Green-Star certification for concrete production facilities and the Sustainable Plant Guidelines that will document continuous improvement toward sustainable concrete production.

Aspects of project specifications, however, restrict the industry toward achieving its sustainable goals. Some of these are based on code requirements. Some are based on prescriptive limits invoked for an intended performance attribute. It is generally accepted that project specifications that minimize prescriptions or that incorporate performance-based requirements allow knowledgeable concrete suppliers to optimize concrete mixtures for performance required in its plastic and hardened states. The NRMCA P2P Initiative has been working to evolve specifications to performance-based requirements. Some of the typical specification requirements that impact sustainable construction identified by the committee are briefly discussed in this article.

The general concepts are that specifications should permit the use of regionally available materials that minimize transportation, avoiding restrictions on material ingredients beyond those in reference material specifications, permit the ability to increase the recycled content in concrete mixtures and minimize waste incurring disposal management and cost, minimize the carbon footprint of concrete mixtures, and incorporate aspects that maximize the environmental (life cycle assessment) and service life performance of concrete as a construction material.

Restriction on ingredient materials

Specifications place restrictions on the source and type of ingredient materials that can be used in concrete. These restrictions may force the use of materials unfamiliar to the producer, require a greater over-design, cause incompatibility with other materials and require material to be transported longer distance. In most cases, concrete mixtures can be optimized with available materials to meet the needs of a project. Prohibiting acceptable products inhibits the concrete producer from optimizing concrete mixtures. These restrictions do not support sustainable development and can adversely impact performance of concrete.

Cement Type and source: Specifications often restrict a type (e.g. ASTM Type II) of cement or restrict use to certain sources. These are appropriate only if there is a code requirement or specific reason for durability or other property.

Cement Specification: Specifications often restrict the use of cements conforming to ASTM C150. Blended cements conforming to ASTM C595 and performance cements conforming to ASTM C1157 are optimized for performance by cement manufacturers and often have a lower carbon footprint per unit of product.

Low alkali cement: Specifications often require the use of a low alkali cement to minimize the occurrence of deleterious expansive cracking due to alkali silica reactions. Manufacturing low alkali cements increases the use of natural resources and energy and increases the generation of cement kiln dust (CKD) as a waste byproduct. Mitigation of alkali silica reactions with locally available potentially reactive aggregates can be accomplished and documented by tests using supplementary cementitious materials and admixtures.

Type and characteristics of SCMs: Specifications often prohibit the use of some types of supplementary cementitious materials or impose restrictions over and above those in the material specifications – such as on alkali content, loss on ignition or grade of slag cement. These will prevent the use of locally available materials that likely have good past performance and will require materials to be imported.

Type and brand of admixtures: Most specifications include a list of specific admixture brands and suppliers. There are situations where specifying a specific brand is appropriate for performance or historical reasons. Concrete producers have experience with use of certain products and forcing the use of a new product will impact the ability of the concrete producer to provide concrete mixtures of consistent quality and performance.

Type and source of aggregate: Specifications may restrict the aggregate type and require the use of a specific source – crushed vs. gravel, mineralogy, specific supplier or source, etc.

Characteristics of aggregates: Specifications often place restrictions on the characteristics of aggregates, such as grading, specific gravity, particle shape and size. In some areas, local aggregate supplies may not comply with all requirements of referenced specifications, such as ASTM C33, but have a good history of use.

Use of potable water: ASTM C1602 addresses the quality of water that can be used to produce concrete and includes provisions to permit the use of non-potable water with proper testing and evaluation. Specifications that require the use of potable water detract from the development and use of sound environmental management practice and negate the associated capital investment for best environmental management practices at concrete production facilities.

Recycled materials and aggregates: There are applications for concrete that can accommodate the use of recycled aggregates or other materials with minimal impact to concrete quality. Crushed returned concrete can be used as a portion of the aggregate in structural fills and footing applications, for example, and conserves virgin material resources. The use of recycled material can contribute to credits in green construction rating systems. The use of crushed concrete as aggregate is recognized in industry standards. Judicious use of these materials conserves natural resources and landfill space with minimal impact to required performance.

Requirements on concrete mixtures

Some limitations on concrete mixtures in project specifications impact the ability to optimize the mixtures for placement, can result in significant overdesign or adversely impact other properties. In most cases these requirements will detract from sustainable concrete mixtures.

Minimum cement content: Many specifications impose minimum cement contents for different classes of concrete. These limits impact meeting environmental goals with questionable benefits to quality, performance and durability.

Quantity of SCM: Specifications place maximum limits on the quantity of supplementary cementitious materials. This prevents optimizing concrete mixtures for performance and durability. The only code restriction on the quantity of SCM is for exterior concrete subject to application of deicing chemicals.

Increasingly, projects seeking green construction credits impose prescriptive requirements on concrete mixtures, such as a minimum replacement for cement or minimum recycled content. These requirements can often impact the performance of fresh and hardened concrete properties, such as setting characteristics, ability to place and finish and rate of development of in-place properties. In the long run this may impact the quality of construction or the service life of the structure.

Max w/cm when not required: The code requires the use of a maximum w/cm for durability and assigns a minimum specified strength that is in alignment with the required w/cm. Many specifications invoke limits on w/cm for elements not subject to severe service exposure conditions. This includes all interior concrete. Imposing a low w/cm limit likely increases the cement content of concrete mixtures and affects the ability to place and finish concrete.

Inconsistent specified strength to design: Concrete members in a structure are often designed for different strength levels – requirements for foundations may differ from beams and columns; slabs may have different requirements. Specifications may, however, specify the same class for all concrete on a project. This can cause problems during placing and finishing some members. There are considerable cost savings and environmental benefits if the concrete is specified as required for the different structural members on a project. When a higher strength is specified, the designer should use that to advantage when designing the structure and minimize section size when applicable.

Air content: Most specifications require a constant air content requirement regardless of aggregate size and often increase it, assuming this will improve freeze-thaw durability. Air content requirements for concrete vary by aggregate size. In many exterior vertical members that will not be critically saturated and have a high strength and for interior concrete, air entrained concrete may not be required. Air content reduces strength and additional cement is required to offset this strength decrease. This can result in increased propensity for thermal and shrinkage cracking.

Restriction on changes to mixtures: Ingredient materials vary as do environmental conditions at the project. Real time adjustments are necessary to concrete batches to accommodate these variations and to ensure consistent concrete characteristics. Several specifications prohibit such minor changes to concrete unless a submittal, often with supporting test data, is provided to the engineer of record. It is recognized that the engineer of record should be notified for major revisions to mixtures, but this prohibition can cause considerable variation to concrete performance.

Use of test record for submittals: Specifications often indicate that the concrete mixture should be designed to produce an average strength at a fixed value greater than the specified strength. This essentially prohibits the use of a past test record that allows for a statistically based average strength level that can be lower than that set by the specification. This benefits concrete producers that have good control to optimize concrete mixtures to a lower strength level and thereby conserve materials.

Reliable testing

Test results are used to establish the average strength for concrete mixtures. Improper testing contributes a significant component of the variability of test results that will increase the required average strength for future projects. When concrete producers are aware of improper testing, they protect themselves by increasing the cementitious materials in concrete mixtures. Owners should select testing agencies based on quality of work, conformance to ASTM C1077 and having certified personnel performing testing.

Conclusion

Requirements in project specifications need to be in concert with the goals for sustainable concrete construction. Some examples where these do not work hand-in-hand are illustrated. The evolution toward performance specifications that address the needs of the contractor for placing concrete and the design professional for the structural and serviceability requirements of the structure needs to occur. Specifications should permit the appropriate flexibility for conserving resources and facilitating innovation. Concrete construction needs to be competitive with other building materials in the current environment that emphasizes on green and sustainable construction. ■

This article is an excerpt from a document on specifications and sustainability under development by the NRMCA P2P Steering Committee. For more information, contact Dr. Lobo at clobo@nrmca.org.