How do we Promote Performance-based Specifications?

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Promoting Performance based specifications
Topics to be explored

- Benefits to the designer, owner and ready mix concrete producer on using performance-based specifications,
- Understanding the root cause of why performance-based specifications are not widely used,
- What can we do to promote performance-based specifications (case studies of where performance specifications have been successfully accepted - lessons learnt)?
- Recommended “next steps”.

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1. Economics
   a) The prescriptive effect on the ready mix concrete producer
      - What is the effect on producers in markets where the bulk of concrete produced is prescriptive?
        - challenge to optimize and collect test data
        - numerous mixes (average number of mixes can be 2,900 to 3,500)
        - over design - additional cementitious content - cost to the ready mix producer along with cost to the owner (can result in lack of standard deviation optimization, because of too many mixes)
        - additional cost of required QC technicians, cylinders, trial mixes...
      - Switching of raw materials in markets (shortages of fly ash, cement supply changes etc.) requires additional testing & resubmitting for mix approval
   b) Quantifying the cost benefits to the owner/developer
      - Performance specification should provide the best value and ensure that the owner receives the most benefits and the contractor selects cost effective materials and methods of construction.
      - Performance specifications are designed to reduce the risk to owner, by making the contractor responsible for the outcome.
      - In turn, the contractor benefits by being able to use innovative materials and construction methodology.

2. Performance versus Prescriptive
   Why is performance based concrete not popular in the USA?

<table>
<thead>
<tr>
<th>PRESCRIPTIVE</th>
<th>VS PERFORMANCE</th>
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<td>Details the materials that must be used &amp; to a certain extent, the methods &amp; procedures to achieve the end result</td>
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<td>Limits the contractor and concrete supplier’s innovativeness</td>
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<td>Design responsibility with the specifier - specifier feels he/she has full control and the design is their responsibility.</td>
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<td>Has a wide range of design solutions</td>
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<td>States requirements in terms of required results with criteria for verifying compliance</td>
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<td>Defines the functional requirements and the environment in which it must operate</td>
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<td>Specifiers focus on what is needed, rather than on how to get it</td>
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2. Performance versus Prescriptive

What are the Issues with Performance-based Specifications?

- Defining what is desired – defining performance is a relatively “new” concept to many specifiers
- Wide range of design solutions
- Determining what initial tests will prove it
- Determining which QA/QC tests are needed to validate
- Risk of non-compliance: requires a knowledgeable contractor and a credible ready mix supplier
- Advanced notice of all these requirements (many are long term tests, some of which can be costly)
  - A team of contractors and suppliers prepared to undertake the testing and trial mixes
  - Some of the jobs are ready to start before the required testing is completed

Where are Performance-based specifications used today?

  - https://www.fhwa.dot.gov/construction/pssr0402.cfm
- Large multi-year projects (bridges/dams/tunnels)
  - Placement does not occur early in project
  - e.g. Port Authority of NY/NJ
- Cutting edge highly technical mixes
  - Testing needed anyway
  - Example very high strength mixes (14,000 psi high rises)
  - Also tested for, modulus of elasticity
  - Occasionally creep (very long test)
- Performance-based specs also exist with Industrial Slabs

Why Performance-based specification often don’t work?

- Owners/specifiers often do not know what is important
- Most building code standards are predominantly prescriptive in nature
- Lack of standardized test procedures for evaluating concrete performance
- Performance mixes can be optimized, but require extensive, costly testing
- Allocation of risk is not always transparent.

Success converting to performance

- Elevated Beams, 12th floor, cantilever.
- Each beam takes several hundred cubic yards of concrete.
- Cross Section of beam is 6’ W by 20’ H.
- Heavy reinforcing steel and post-tension cables.
- Very small steel cover
- Fc = 6000 psi @ 28 days.
- A/E specified 6000 psi, “Mass Concrete”.
- Steel congestion requires small aggregate.
- Difficult to consolidate, contractor wants a very high slump, but not SCC.
- Height of forms require concrete to lose slump rapidly (reduce liquid head).
- Post tensioning schedule requires high early strength.

Steel congestion requires small aggregate
- Original mix required nominal 1” aggregate
- 3/8” nominal maximum size crushed stone is chosen
- Smaller aggregate increases basic water demand of concrete
- Smaller aggregate increases cementitious content for a given strength

Performance versus Prescriptive: Case Study

Owner Specified 6000 psi “Mass Concrete”
- Low heat of hydration
- Low water cement ratio
- High Pozzolanic replacement ratio
- Slower set time of concrete
- Slow strength development
- Reduced cementitious content for lower heat development

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- Difficult to consolidate, contractor wants a very high slump, but not SCC
  - Need to pump 14 stories without significant slump loss
  - Slump requested is in the 10.5 to 11.5 range
- Height of forms require concrete to lose slump rapidly (reduce liquid head)
  - Required slump loss in forms "like" normal concrete,
  - Risk of form failure due to excessive liquid head.
  - Note: high slump, high volume fly ash, low heat of hydration, no slump loss while pumping
- Post tensioning schedule require high early strength
  - Required 75% of f’c in 48-72 hours
  - Note: high slump, high volume fly ash, low heat of hydration, no slump loss while pumping

2. Performance versus Prescriptive: Case Study

- Not much makes sense
- Each requirement seems to contradict each other
- Every party has a different agenda
- How does this happen?

Typical Communication Flow

Typical Communication Flow

A/E  GC  Concrete Contractor  R/M Producer

3. Promoting Performance

How do we promote performance specifications?

Performance - needs to gain confidence in the market
- Communication - engineers, contractors and concrete suppliers need to partner together, early communication allows sufficient time to undertake additional testing and/or trial mixes (esp. for 28 day strength),
- Understand potential economic benefits: education on potential over design and costs, limitations on innovative construction & mix optimization,
- Highlight success stories, develop case studies, lessons learnt.

4. Next steps

Our recommendation

- Short pulse survey engineering & architectural community:
  - gain understanding of knowledge of engineers on performance & the barriers to using performance specifications,
- NRMCA member research to estimate / quantify cost of prescriptive vs performance,
- Measure/quantify the size of the performance versus prescriptive market,
- Continue ongoing education of purchasers and engineers on performance,
- One pager promotional material on performance.
Addendum

References

- NRMCA website: www.nrmca.org/p2p
- Guide to improving specifications
- Specification in Practice series
- American Concrete Institute
- ACI Committee 329 report on performance specifications
- Why Performance-based Specifications for Concrete?, Vijay Kulkarni (President, Indian Concrete Institute)