

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 2,500 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

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1. Economics
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.

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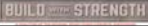
2. Performance versus Prescriptive
Why is performance based concrete not popular in the USA?

PRESCRIPTIVE	VS	PERFORMANCE
<ul style="list-style-type: none"> • Details the materials that must be used & to a certain extent, the methods & procedures to achieve the end result • Limits the contractor and concrete supplier's innovativeness • Design responsibility with the specifier - specifier feels he/she has full control and the design is their responsibility. 		<ul style="list-style-type: none"> • Has a wide range of design solutions • States requirements in terms of required results with criteria for verifying compliance • Defines the functional requirements and the environment in which it must operate • Specifiers focus on what is needed, rather than on how to get it.

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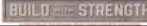
2. Performance versus Prescriptive
What are the Issues with Performance-based Specifications?

- 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


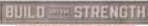
2. Performance versus Prescriptive
Where are Performance-based specifications used today?

- US Department of Highway (Performance Specifications Strategic Roadmap: A Vision for the Future)
 - <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
 - Shrinkage specifications
 - Sometimes curling is specified

2. Performance versus Prescriptive
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.


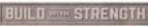
2. Performance versus Prescriptive: Case Study




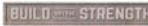
2. Performance versus Prescriptive: Case Study
Success converting to performance

- Elevated Beams, 12th floor, cantilever,
- Each beams 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
- F'c = 6000 psi @ 28days.
- 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.


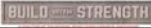
2. Performance versus Prescriptive: Case Study

- A/E 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
- 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

2. Performance versus Prescriptive: Case Study

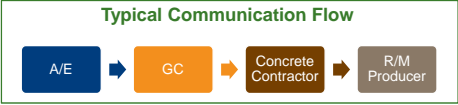
- Difficult to consolidate, contractor wants a very high slump, but not SCC
 - Need to pump 14 stories without significant slump loss
 - Slump requested is in the 10.5 to 11.5 range
- Height of forms require concrete to lose slump rapidly (reduce liquid head)
 - Required slump loss in forms "like" normal 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
 - Remember: high slump, high volume fly ash, low heat of hydration, no slump loss while pumping

2. Performance versus Prescriptive: Case Study


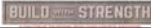
- Not much makes sense
- Each requirement seems to contradict each other
- Every party has a different agenda
- How does this happen?

Typical Communication Flow



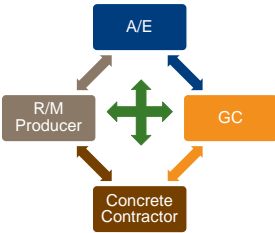
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    graph LR
      A[E] --> GC
      GC --> CC[Concrete Contractor]
      CC --> RMP[R/M Producer]
    
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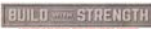
2. Performance versus Prescriptive: Case Study

Ideal Communication Flow



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    graph TD
      A[E] <--> GC
      GC <--> CC[Concrete Contractor]
      CC <--> RMP[R/M Producer]
      RMP <--> A[E]
      A[E] <--> RMP
      GC <--> RMP
    
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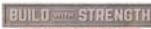



3. Promoting Performance

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

- Continue ongoing education of owners/developers and engineers on performance,
- Develop succinct concise educational presentation to support performance specification (one pager),



- Short pulse survey engineering & architectural community
- gain understanding of performance & barriers to using performance specifications.


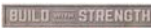
- NRMCA member research to estimate / quantify cost of prescriptive vs performance,
- Measure current market size of performance, track Y-o-Y.

4. Next steps

Our recommendation

- Understand current knowledge of engineers on performance & the barriers to using performance specifications,
- Quantify the cost of prescriptive mixes versus 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
- *Specifications: Prescriptive to Performance*, W.S. Langley, M.Eng., P.Eng. FCSCE, FACI (Collaborative Seminar Series 2005/2006)
- *Why Performance-based Specifications for Concrete?*, Vijay Kulkarni (President, Indian Concrete Institute)

