Ready-Mix Concrete Standards

Richard S. Szecsy, PhD, PE, FACI
President
Texas Aggregates and Concrete Association

Riyadh, Saudi Arabia
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Connections between Specifications

Materials
- C33 Agg.
- C1602 Water
- C150 Cement
- C618 Ash
- C290 Air
- C494 Admix

C49 Ready-Mix

Sampling
- C172 Sampling Fresh Concrete

Testing
- C39 Strength
- C231 Air
- C143 Slump
- C1064 Temp
Specification covers ready-mixed concrete as defined in 3.2.2. Requirements for quality of concrete shall be either as hereinafter specified or as specified by the purchaser. In any case where the requirements of the purchaser differ from these in this specification, the purchaser's specification shall govern. This specification does not cover the placement, consolidation, curing, or protection of the concrete after delivery to the purchaser.

3.2.2 concrete, ready-mixed, n—concrete manufactured and delivered to a purchaser in a fresh state.
• **Relationship between**
  
  – Manufacturer and Purchaser.
  
  – Not specifier, owner, contractor, etc.

- Basis of Purchase
- Materials
- Ordering
- Measuring
- Mixing and Delivery
- Batch Ticket Information
- Sampling & Testing
- Strength
4.0 Basis of Purchase

4.1 The basis of purchase shall be a **cubic yard** or **cubic metre** of fresh concrete as discharged from the transportation unit.
5.0 Materials

NOTE 2—In any given instance, the required dosage of air-entraining, accelerating, and retarding admixtures may vary. Therefore, a range of dosages should be allowed which will permit obtaining the desired effect.

NOTE 3—Interchanging kinds, characteristics, types, classes, or grades of the materials permitted in ready-mixed concrete may produce concrete of different properties.
6.3 **Option A:**

6.3.1 When the purchaser requires the manufacturer to assume **full responsibility** for the selection of the **proportions** for the concrete mixture (Note 7),

**Note 7**—The purchaser, in selecting requirements for which he assumes responsibility should give consideration to requirements for **workability, placeability, durability**, surface texture, and density, in addition to those for structural design. The purchaser is referred to Standard Practice ACI 211.1 and Standard Practice ACI 211.2 for the selection of proportions that will result in concrete suitable for various types of structures and conditions of exposure. The water-cement ratio of most structural lightweight concretes cannot be determined with sufficient accuracy for use as a specification basis.
6.0 Ordering

6.4 Option B:

6.4.1 When the purchaser assumes responsibility for the proportioning of the concrete mixture, he shall also specify the following:

6.4.1.1 Cement content in pounds per cubic yard [kilograms per cubic metre] of concrete,

6.4.1.2 Maximum allowable water content in gallons per cubic yard [litres per cubic metre] of concrete, including surface moisture on the aggregates, but excluding water of absorption (Note 7), and

6.4.1.3 If admixtures are required, the type, name, and dosage to be used. The cement content shall not be reduced when admixtures are used under this option without the written approval of the purchaser.
6.0 Ordering

6.5 Option C:

- 6.5.1 When the *purchaser requires the manufacturer* to assume responsibility for the selection of the proportions for the concrete mixture with the *minimum allowable cement content* specified (Note 8),

Note 8—Option C can be distinctive and useful *only if the designated minimum cement content is at about the same level that would ordinarily be required for the strength, aggregate size, and slump or slump flow specified*. At the same time, it must be an amount that will be sufficient to ensure durability under expected service conditions, as well as satisfactory surface texture and density, in the event specified strength is attained with it.
Prescriptive vs. Performance Ordering Options

• ASTM C94 Section 6
  – 6.3 Option A: When the Purchaser requires the manufacturer to assume full responsibility for the selection of the proportions for the concrete mixture.
  – 6.4 Option B: When the purchaser assumes responsibility for the proportioning of the concrete mixture.
  – 6.5 Option C: When the Purchaser requires the manufacturer to assume responsibility for the selection of the proportions for the concrete mixture with the minimum allowable cement content specified.
# Current Ordering Performance Accountability

<table>
<thead>
<tr>
<th>Option</th>
<th>Specifier</th>
<th>Purchaser</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Option A</strong></td>
<td><strong>Manufacturer assumes full responsibility for proportions</strong></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>Option B</strong></td>
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<td><strong>Purchaser assumes full responsibility for proportions</strong></td>
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<td><strong>Option C</strong></td>
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<td><strong>Manufacturer assumes full responsibility for proportions, with minimum cement content from Purchaser</strong></td>
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<tr>
<td>Option A</td>
<td>Specification</td>
<td>Purchaser</td>
<td>Manufacturer</td>
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<th>Manufacturer</th>
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<table>
<thead>
<tr>
<th>Option C</th>
<th>Specification</th>
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<tbody>
<tr>
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## Prescriptive and Performance Ordering Options

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## Performance

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<th>Specifier</th>
<th>Purchaser</th>
<th>Manufacturer</th>
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<tbody>
<tr>
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# Prescriptive and Performance Ordering Options

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<tr>
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<th>Concrete Performance Accountability</th>
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<tbody>
<tr>
<td><strong>Specifier</strong></td>
<td><strong>Purchaser</strong></td>
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<tr>
<td><strong>Prescriptive</strong></td>
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<tr>
<td>Purchaser assumes full responsibility for proportions</td>
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<tr>
<td><strong>Performance</strong></td>
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<tr>
<td>Manufacturer assumes full responsibility for proportions</td>
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## Comparison

<table>
<thead>
<tr>
<th>Order Option</th>
<th>Mix Proportion Responsibility</th>
<th>Performance Accountability</th>
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</thead>
<tbody>
<tr>
<td>Option A</td>
<td>Manufacturer</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>Option B</td>
<td>Purchaser</td>
<td>Manufacturer</td>
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<tr>
<td>Option C</td>
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<td>Purchaser</td>
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<tr>
<td>“Performance”</td>
<td>Manufacturer</td>
<td>Manufacturer</td>
</tr>
</tbody>
</table>
9.0 Measuring Materials

- **Tolerances for measurement:**
  - Cementitious materials ±1% cumulative mass
  - Aggregates (cumulative) ±3% required mass
  - Aggregates (discrete) ±2% required mass
  - Water ±3% cumulative mass
    - Water added to the batch,
    - Ice added to the batch,
    - Water occurring as surface moisture on the aggregates,
    - Water introduced in the form of admixtures
  - Chemical admixtures ±2% required amount (mass or vol.)
12.0 Mixing & Delivery

- **Three types of mixing:**
  - 12.1.1 Central-Mixed Concrete
  - 12.1.2 Shrink-Mixed Concrete
  - 12.1.3 Truck-Mixed Concrete

- **Uniformity testing is a requirement**

- **Time and drum rev. limits (more on this later...)**

- **Temperature limits?**
  12.11 The producer shall deliver the ready mixed concrete during hot weather at concrete temperatures as low as practicable, subject to the approval of the purchaser.

  **Note 21**—In some situations difficulty may be encountered when concrete temperatures approach 90 °F [32 °C]. Additional information may be found in ACI 305R.
# 14.0 Batch Ticket Information

<table>
<thead>
<tr>
<th>14.1 Mandatory</th>
<th>14.2 Non-Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company, batch plant (or #)</td>
<td>Rev reading at beginning</td>
</tr>
<tr>
<td>Serial number of ticket</td>
<td>Type, brand, amt of cement</td>
</tr>
<tr>
<td>Date</td>
<td>Class brand, amt of pozz.</td>
</tr>
<tr>
<td>Truck #</td>
<td>Type brand, amt of admix</td>
</tr>
<tr>
<td>Name of Purchaser</td>
<td>Source of each water</td>
</tr>
<tr>
<td>Job designation</td>
<td>Info to calculate total mixing water</td>
</tr>
<tr>
<td>Class/designation of concrete</td>
<td>Max agg. Size</td>
</tr>
<tr>
<td>Amount of concrete (vol.)</td>
<td>Mass of fine and coarse agg.</td>
</tr>
<tr>
<td>Time loaded or first mixing</td>
<td>All ingredients previously approved</td>
</tr>
<tr>
<td>Amount of water added</td>
<td>Signature of producer</td>
</tr>
<tr>
<td>Amount of water added in transit</td>
<td></td>
</tr>
<tr>
<td>Revolution limit</td>
<td></td>
</tr>
</tbody>
</table>
17.0 Sampling & Testing Fresh Concrete

17.1 The contractor shall afford the inspector all reasonable access and assistance, without charge, for the procurement of samples of fresh concrete at time of placement to determine conformance of it to this specification.

17.2 Tests of concrete required to determine compliance with this specification shall be made by a certified technician in accordance with Practice C1077.

17.3 Samples of concrete shall be obtained in accordance with Practice C172/C172M, except when taken to determine uniformity of slump within any one batch or load of concrete (11.4, 12.3.3, 12.5.1, and 13.4).
17.0 Sampling & Testing Fresh Concrete

- **Only four tests mentioned:**
  - Slump or slump flow (C143) or (C1611)
  - Strength (C39)
  - Air content (C231) or (C173)
  - Density (C138)

- **Check tests are allowed without rejection**
  - Slump, slump flow, and air content
18.0 Strength

18.1 When strength is used as a basis for acceptance of concrete, standard specimens shall be made in accordance to Practice C31/C31M. The specimens shall be cured under standard moisture and temperature conditions in accordance with the applicable provisions of Practice C31/C31M.

18.2 For a strength test, at least two standard test specimens shall be made from a composite sample secured as required in Section 17. A test shall be the average of the strengths of the specimens tested at the age specified in 6.3.1.1 or 6.5.1.1 (Note 24). If a specimen shows definite evidence other than low strength, of improper sampling, molding, handling, curing, or testing, it shall be discarded and the strength of the remaining cylinder shall then be considered the test result.
Recent Changes in C94

• What does a sack of cement weigh?
• What happens strengths are low?
• Do I reject concrete at 300 revolutions?
• Do I reject concrete at 90 minutes?
• What about ASR, ACR, etc?
• Returned Concrete
• Failure to meet strength
ASTM C94/C94M – 09

Section 9 Measuring Materials

Under special circumstances approved by the purchaser, hydraulic cement is permitted to be measured in bags of standard mass (Note 9). No fraction of a bag of hydraulic cement shall be used unless its mass has been determined.

NOTE 9—In the United States the standard mass of a bag of portland cement is 94 lb [42.6 kg] 6 ‰.
What does a sack of cement weigh? (Now)

ASTM C94/C94M – 13a

Section 9 Measuring Materials
When the purchaser requires alternate methods of measuring cementitious materials, measurement methods and reporting shall be stated in the order (see Note 11).

NOTE 11—Cementitious materials in bags may be used when requested by the purchaser.
Section 19 Failure to Meet Strength Requirements

In the event that concrete tested in accordance with the requirements of Section 18 fails to meet the strength requirements of this specification, the manufacturer of the ready mixed concrete and the purchaser shall confer to determine whether agreement can be reached as to what adjustment, if any, shall be made. If an agreement on a mutually satisfactory adjustment cannot be reached by the manufacturer and the purchaser, a decision shall be made by a panel of three qualified engineers, one of whom shall be designated by the purchaser, one by the manufacturer, and the third chosen by these two members of the panel. The question of responsibility for the cost of such arbitration shall be determined by the panel. Its decision shall be binding, except as modified by a court decision.
Section 19 Failure to Meet Strength Requirements

In the event that concrete tested in accordance with the requirements of Section 18 fails to meet the strength requirements of this specification, the manufacturer of the ready-mixed concrete and the purchaser shall confer to determine whether agreement can be reached as to what adjustment or adjustments, if any, shall be made to the mixture proportions, production process, or testing procedures.

NOTE 26—Section R5.6.3.4 of the ACI 318–11 Commentary and Section 5.6.5 of ACI 318–11 and its respective Commentary address when and how low strength test results and the quality of in-place concrete can be investigated.
300 Drum Revolutions (and 90 minutes)

![Graph showing compressive strength for different drum revolutions. The design requirement is marked as 'REJECTION'.]
300 Drum Revolutions (and 90 minutes)

- Compressive strength (psi)
- Time (min)

Graph shows the relationship between revolutions and compressive strength over time.
12.7 Discharge of the concrete shall be completed within 1-1/2 h, or before the drum has revolved 300 revolutions, whichever comes first, after the introduction of the mixing water to the cement and aggregates or the introduction of the cement to the aggregates.
6.1.8 Purchaser shall state any drum revolution limit as to when the concrete discharge must begin. If no drum revolution limit is stated by purchaser, the manufacturer shall determine and communicate the limit to the purchaser prior to delivery.

NOTE 4—An example of a drum revolution limit would be “XXX” revolutions.
12.8 When a drum revolution limit (6.1.8) for start of discharge is specified by the purchaser, this limit shall govern.

NOTE 19—Depending on the project requirements the technology is available to the manufacturer to alter fresh concrete properties (such as setting time, slump or slump flow, air content, etc.). On some projects the manufacturer may request changes to certain fresh concrete properties due to the distance or projected transportation time between the batch plant and the point of delivery.
What about 90 minutes?
ASR & ACR?

- **C09.50**
  - Risk Management for Alkali Aggregate Reaction

- **Sole Document**
  - *New Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete*
  - Focuses on flow chart for management (decision making) on how to identify risk of AAR
  - Based on AASHTO flow chart
Returned Concrete in ASTM C94

• Top loaded concrete as a material source?
• Industry already does it
• A sustainable practice?
• How to incorporate and manage?
19.0 Failure to Meet Strength Requirements

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NOTE 26—Section R5.6.3.4 of the ACI 318–11 Commentary and Section 5.6.5 of ACI 318–11 and its respective Commentary address when and how low strength test results and the quality of in-place concrete can be investigated.
Questions

Richard S. Szecsy, PhD, PE
President

Texas Aggregates and Concrete Assoc.
900 Congress
Austin, Texas 78701
214-202-1379 cell
512-451-5100 ofc

rich.szecsy@tx-taca.org
www.tx-taca.org