Municipal Specification Conflicts with Green Building and Sustainable Design

As Specifically Related to Concrete and Cement

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Spring 2010
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Overview

- North Texas Market
- Municipal restrictions on cement
  - Dallas, Texas as an example
- Law of Unintended Consequences
Sustainable Design Philosophy

\[ \text{Sustainability} = \frac{\text{Design Requirement}}{\text{Design Function}} \times \frac{\text{Time}}{\text{Sustainability}} \]

- **Design Requirement**
  - Specified level of performance necessary

- **Design Function**
  - Specified intent for use of the structure from the Owner
Sustainable Design Philosophy

Design Requirement = Performance
Sustainable Design Philosophy

\[ \text{Sustainability} = \frac{\text{Performance} > \text{Function}}{\text{Time}} \]

- **Performance**
  - Expected result from the design as measured by a standard method

- **Function**
  - Intended use of structure or structural element
Design Philosophy

Prescription $\cong$ Performance

- Generally accepted design approach
- Supported by Codes and Standards
- Don’t have to exercise judgment
- Perception that it minimizes liability
**Design Philosophy**

\[
Sustainability = \frac{\text{Prescription} > \text{Function}}{\text{Time}}
\]

- Is it possible to “prescribe” sustainability?
- Does a prescriptive approach create an inherent conflict?
- How do we resolve the conflict?

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North Texas Market Statistics

- **Consumes 16.0M yd³/yr (normally...)**
  - About 3.0 yds per capita

- **Requires about 4.0M tons of cement**

- **Additional 0.3M tons for precast, block, pipe, etc.**

- **Midlothian cement mills produce 5.8M tons per year**
  - Producing at maximum capacity

- **Importing 1.0M tons to supply demand**
Concrete Demographics

- Market divided into 3 categories
  - Residential, Commercial and Municipal

- City of Dallas has 1,200,000+ residents, 2006 census
  - About 3.6M yd$^3$ of concrete
    \[\approx 913,680 \text{ tons of cement}\]
  - 1.44M yd$^3$ of commercial (40%)
  - 1.26M yd$^3$ of municipal (35%)
    \[\approx 379,008 \text{ tons of cement}\]
  - 0.9M yd$^3$ of residential (25%)
Concrete Economics

• **Price per yard (yd$^3$) driven by sack content**
  – Sack content is total cementitious material
  – Higher the sack content = higher concrete expense
  – Lower the sack content = lower concrete expense

• **More limited/specialty a source material…**
  – …the more expensive it becomes…
  – …the greater the concrete expense
  – Simple supply and demand economics
Cement as a Raw Material

- 1.0 ton of cement is responsible for:
  - 0.9 tons of CO$_2$
  - 1.7 to 4.0 lbs of NO$_x$

- Cement can be replaced by fly ash
  - Fly ash is a waste material from coal fired power plants
  - Product is landfilled otherwise
  - 1.0 lb of cement is replaced by 1.0 lb of fly ash
First Principles of the Reaction

Cementitious Reaction

\[ C_3S + H \rightarrow CSH + CH \]

Cement + Water \( \rightarrow \) CSH + Lime

Pozzolanic Reaction

\[ CH + S + H \rightarrow CSH \]

Lime + Pozz + Water \( \rightarrow \) CSH
Clean Air Initiative and progress?

- Demand for cement is higher than supply (normally…)
- Currently importing cement into North Texas
- Limiting the cement based on emissions to improve North Texas air quality?
It started with Dallas...

- City of Dallas
- City of Ft. Worth
  (has since amended...)
- City of Arlington
- City of Irving
- City of Plano

“...A cement kiln that has met the emission standard of 1.7 lb of NO_x per ton of clinker released into the atmosphere...”
## Municipal Contradictions - Dallas

City of Dallas Specifications for Concrete, Section 5.8.1.1

<table>
<thead>
<tr>
<th>Class of Concrete</th>
<th>Min cement content per cu.yd.</th>
<th>Min. comp. Str. 28 day, psi</th>
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**Note:** 1 sack = 94.0 lbs of cementitious material
## Municipal Contradictions - Dallas

City of Dallas Structural Concrete specifications, Section 7.4.5.b.

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City of Dallas Restrictions

• **Prohibits the use of fly ash**
  – Section 5.8.1.1 of the October 1996 City of Dallas Public Works, pg 38, it states, “Fly Ash Shall not be used in hand finish concrete”

• **Restricts the use of fly ash**
  – Section 2.2.2.d, “…the maximum cement reduction shall not exceed 20% by weight of cement…”

• **Replaces at a 1.0:1.25 ratio?!?!**
  – Section 2.2.2.d, “…fly ash replacement shall be 1.25 pounds, per 1.0 pound of Portland cement…”
City of Dallas Example

- Paving with 4500 psi requirement
- Hand paving
- City of Dallas specifications (5.8.1.1) state:

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## City of Dallas Comparison

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<thead>
<tr>
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<th>COD (no ash)</th>
<th>Industry</th>
<th>COD (w/ash)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Cement Content =</td>
<td>611</td>
<td>564</td>
<td>611</td>
</tr>
<tr>
<td>Sack Content =</td>
<td>6.5</td>
<td>6.0</td>
<td>6.5</td>
</tr>
<tr>
<td>Cement to Ash replacement =</td>
<td>1.0</td>
<td>1.0</td>
<td>1.25</td>
</tr>
<tr>
<td>Max replacement =</td>
<td>0%</td>
<td>25%</td>
<td>20%</td>
</tr>
<tr>
<td>Cement wt =</td>
<td>611</td>
<td>423</td>
<td>509</td>
</tr>
<tr>
<td>Ash wt =</td>
<td>0</td>
<td>141</td>
<td>127</td>
</tr>
<tr>
<td>New Cement content =</td>
<td>611</td>
<td>564</td>
<td>636</td>
</tr>
<tr>
<td>New Sack Content =</td>
<td>6.5</td>
<td>6.0</td>
<td>6.8</td>
</tr>
<tr>
<td>NO\textsubscript{x} per yard (lbs.) =</td>
<td>0.92</td>
<td>0.63</td>
<td>0.76</td>
</tr>
<tr>
<td>CO\textsubscript{2} per yard (tons) =</td>
<td>0.27</td>
<td>0.19</td>
<td>0.23</td>
</tr>
<tr>
<td>$ per yard =</td>
<td>$119.50</td>
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## City of Dallas Results

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<th>Item</th>
<th>No fly ash replacement</th>
<th>Fly Ash replacement</th>
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<tbody>
<tr>
<td>NO\textsubscript{x} per cubic yard</td>
<td>33% increase</td>
<td>10% increase</td>
</tr>
<tr>
<td>CO\textsubscript{2} per cubic yard</td>
<td>29% increase</td>
<td>10% increase</td>
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<tr>
<td>Cost</td>
<td>10% increase</td>
<td>11% increase</td>
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*Note:* As compared to an industry standard design

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## City of Dallas Conclusions

- COD concrete specifications prohibit the supply of environmentally conscious concrete
- Counter intuitive to actual concrete production
- Contradict standard industry practice
- Conflict with green building and sustainable design philosophy
### City of Dallas (and others) Action Steps

- Remove minimum cement content
- Remove restrictions on maximum fly ash
- Remove 1:1.25 replacement of cement and fly ash
- Focus on performance aspects of concrete
  - Compressive strength, shrinkage, permeability, etc
  - Results that can be measured by standard test methods
- Don’t focus on prescriptive elements
### Actual and Unintended Consequences

- When supply is limited, but demand is high…
  - …the market responds…
- Concrete prices for municipal has risen 10%
- Concrete production becomes limited
- Job pacing decreases
- Costs escalate
- Did the air quality really change?
Actual and Unintended Consequences

• Lawsuit filed in 2008...
  – Ash Grove Texas, L.P. v. City of Dallas et al, Cause No. 3:08-cv-02114, U.S. District Court, Northern District of Texas, Dallas Division.

• Legal arguments
  – Regulation is arbitrary and capricious
  – Violation of public purchasing laws
  – Preemptive regulation by the municipality
Legal Argument – Arbitrary and Capricious

• Municipality must:
  – Supply a satisfactory and rational analysis
  – Show a rational connection between the facts found and the decision rendered
  – Not rely on improper factors
  – Fails to consider important aspects of the problem
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Legal Argument – Public Purchasing Laws

• If spec has nonfunctional characteristic it violates competitive bidding statute
  – Resolution based entirely on desire to improve air quality and not on a desire to purchase better cement.

• Do not allow specs that are unrelated to the quality or quantity of the goods or services or that otherwise restrict competition.

• Contracts must be awarded to the lowest responsible bidder or to the bidder who provides the goods or services at the best value for the municipality.
Legal Argument – Preemptive regulation

- Attempting to regulate indirectly, what it may not regulate directly
  - TCEQ regulates air quality emissions in State of Texas

- Texas Clean Air Act also prohibits the City’s attempts to regulate around the TCEQ
  - TCEQ has a detailed regulatory scheme and permitted NO\textsubscript{x} emissions on a facility-by-facility basis.

- Could result in about 3000 or more regulators of air quality within the state.
Final Thought

- Environmental Choice:
  - 8.0M tons of cement produce 16.0M yd³ of concrete
  - 8.0M tons of cement produce 18.0M yd³ of concrete

- Which one is better for air quality?

- Otherwise…
  - Limit the choices for cement
  - …where demand outpaces supply
  - …increase the cost for municipal concrete ($10 yd³)
  - …and have zero impact on air quality
  - …headed to a courtroom near you (who pays for defense?)
Questions and Further Information

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szeczy1@lmctx.com
www.lattimorematerials.com
References and Notes


2. Engineering News Record, May 5, 2008, pg. 24. Price listing are for 3000 psi ($92.30), 4000 psi ($94.32), and 5000psi ($96.27) concrete. The Hand Finish concrete is specified as a 4500 psi design. The price per yard of concrete is taken as the average between the 4000 psi and 5000 psi values ($95.30). The value is a ratio between the original design at 6.5 sack and the increase to 6.8 sack and calculated as a simple linear increase, which would be standard industry practice.

3. “White Paper on City of Dallas Concrete Specifications and NO\textsubscript{x} and CO\textsubscript{2} Emissions”, Richard S. Szecsy, PhD, PE, 4807 Arbor Glen, McKinney, Texas, szecsy1@sbcglobal.net, 214-202-1379, October 2007


5. These calculations are based on an average overall sack content of 5.4 (507.6 lb/yd) and an average municipal sack content of 6.4 (601.6 lb./yd). These calculations do not take into account a fly ash replacement.