Let’s Discuss Concrete Batching Operations

A Typical Concrete Batching Operation
246: HMA, Aggregate & Concrete Batching

Overview

- Introduction
- Industry History
- Emissions and Health Impacts
- Concrete Industry Description
- Inspection Procedures
- Engineering Evaluation/Permit Process
How many cubic yards did it take to build?

Concrete Batch Plant
Dry Mix

Constituents

<table>
<thead>
<tr>
<th>Basic Ingredients</th>
</tr>
</thead>
<tbody>
<tr>
<td>11% Portland Cement</td>
</tr>
<tr>
<td>41% Aggregate or Course Stone</td>
</tr>
<tr>
<td>26% Sand</td>
</tr>
<tr>
<td>16% Water</td>
</tr>
<tr>
<td>Balance: Inert Material</td>
</tr>
</tbody>
</table>
What is Concrete

A combination of water, sand, rock, and portland cement mixed together to harden and form.

Composition of Portland cement with chemical composition and weight percent.

<table>
<thead>
<tr>
<th>Cement Compound</th>
<th>Weight Percentage</th>
<th>Chemical Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tricalcium silicate</td>
<td>50 %</td>
<td>Ca$_3$SiO$_5$ or 3CaO SiO$_2$</td>
</tr>
<tr>
<td>Dicalcium silicate</td>
<td>25 %</td>
<td>Ca$_2$SiO$_4$ or 2CaO SiO$_2$</td>
</tr>
<tr>
<td>Tricalcium aluminate</td>
<td>10 %</td>
<td>Ca$_3$Al$_2$O$_6$ or 3CaO Al$_2$O$_3$</td>
</tr>
<tr>
<td>Tetracalcium aluminoferrite</td>
<td>10 %</td>
<td>Ca$_4$Al$_2$Fe$_2$O$_9$ or 4CaO Al$_2$O$_3$ Fe$_2$O$_3$</td>
</tr>
<tr>
<td>Gypsum</td>
<td>5 %</td>
<td>CaSO$_4$.2H$_2$O</td>
</tr>
</tbody>
</table>

Tricalcium silicate + Water →
Calcium silicate hydrate +
Calcium hydroxide + heat

$2\text{Ca}_3\text{SiO}_5 + 7\text{H}_2\text{O} \rightarrow$
$3\text{CaO}2\text{SiO}_2\text{4H}_2\text{O} + 3\text{Ca(OH)}_2 + 173.6\text{kJ}$
Dicalcium silicate + Water $\rightarrow$ 
Calcium silicate hydrate + 
Calcium hydroxide + heat

$2 \text{Ca}_2\text{SiO}_4 + 5 \text{H}_2\text{O} \rightarrow$
$3 \text{CaO} \cdot 2\text{SiO}_2 \cdot 4\text{H}_2\text{O} + \text{Ca(OH)}_2 + 58.6 \text{kJ}$
Cement Delivery Pneumatically

Dust Collectors Serving Cement/Fly Ash/Slag Silos

Purpose/Utility??
Aggregate from a Rock Quarry

Aggregate from a Crushing Plant

Concrete Sand from a Wash Plant
Aggregate Delivery via Conveyors

Aggregate Delivery via Conveyors: Safety

Concrete Batching Process

- Store, convey, measure, and then discharge the ingredients to make concrete into equipment that mixes, packages, or transports the mixture for use.
Dry Ingredients

Additive Ingredients

Ingredients

- Air Retaining Agents
  - Provides resistance

- Water reducing
  - Reduces amount of water needed

- Accelerating Agents
  - Shortens setting or cure time

- Retarding Agents
  - Slows the setting/cure time

- Fungicides
  - Prevents fungal or bacterial growth
Concrete Batching Process

75% of U.S. concrete is produced at plants that
1. Store
2. Convey
3. Measure
4. Mix
5. Discharge into trucks

Types of Concrete Batching Process

- Transit Mix
- Central Mix
- Ready Mix

Concrete Batching Process

- Moisture Sensors
- Scales, load cells
- Silo Weighing and Inventory
- Mixer
- Twin Shaft Mixtures
- Batching Controls
- Load Out

Central Mix

Ready Mix
Concrete Batching Process: Types of Emissions

- Particulate Matter
- Combustion Emissions

Concrete Batching Process

- Sprinkler and Load Out Grizzly

Concrete Batching: Stockpiles
Concrete Batching: Raw Material Receiving & Storage

Concrete Batching: Moisture Sensor

Concrete Batching: Cement Receiving & Storage
Dense-phase Pneumatic Conveying
- Moves material at low velocity to prevent material degradation and equipment wear
- Reduces segregation and promotes flow
- Dry bulk material is typically loaded into a vessel called a transporter
  - Pressurized from 15 to 60 psi
Concrete Batching: Cement Receiving Pneumatic Pump

Concrete Batching: Cement Receiving Silo

Concrete Batching: Cement Loadout
Concrete Batching Process: Central Mix
Concrete Batching Process: Ready Mix

Wait a minute before you loadout!
Concrete Batching Process

Central Mix

Batch Mix

Concrete Batching Process: Batch Mix
**PERP vs Non-PERP**

**Not Portable Equipment**
- Remains in same location more than 12 consecutive months
- Remains in same location less than 12 consecutive months, but production is equal to annual source operations (seasonal sources)
- Unit is moved and returned to the same location

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**Concrete Recycling**

**Crusher** separates metal from Concrete

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Industry Description
Concrete Recycling

Aggregate Storage Piles

Aggregate Storage Piles
Air Quality Concerns

- PM from cement dust & concrete batching process
- 10% to 20% are smaller than 5 microns in diameter
- PM10 & PM2.5 have health impacts

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Inspection Procedures: Bags

Inspection Procedures: Puffing Due to Improper Maintenance
Inspection Procedures: Clogged Bags

Inspection Procedures: Storage Hoppers

Inspection Procedures: Fugitive Dust
Inspection Procedures: Preventative Measures

- Passive enclosures
- Wet suppression & baghouse maintenance
- Paved surfaces Work practices
- Housekeeping

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Inspection Procedures: Preventative Measures

- Water sprays
- Maintaining good housekeeping
- Covers & wind barriers
- Enclosures or hooding transfer points and screening operations
- Air pollution control systems in order

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Inspection Procedures: Preventative Measures

Discharge from Conveyor

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Inspection Procedures: Preventative Measures

Discharge from Piping

Packaging

Lack of Dust Control
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Preventative Measures

Lack of Dust Control

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Inspection Procedures: Preventative Measures

Dust Control

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Inspection Procedures: Preventative Measures

Water Spray System

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Engineering Evaluation
Air Emission Points

1. Deliveries
2. Conveying/Transfer Points
3. Ducting
4. Mixing
5. Shipping/Packaging
6. Reclaim/Slurry Areas
7. Stacks

Engineering Evaluation:
Typical Process
With AP-42 Emission Factors

Engineering Evaluation:
Composition of 1 Cubic Yard of Concrete
(from AP-42)

<table>
<thead>
<tr>
<th>Material</th>
<th>Composition by Weight (lbs/yd³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse Aggregate</td>
<td>1865</td>
</tr>
<tr>
<td>Sand</td>
<td>1428</td>
</tr>
<tr>
<td>Cement</td>
<td>491</td>
</tr>
<tr>
<td>Cement Supplement</td>
<td>73</td>
</tr>
<tr>
<td>Water</td>
<td>20 gallons</td>
</tr>
<tr>
<td>Total Quantity Concrete Produced</td>
<td>4024</td>
</tr>
</tbody>
</table>

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Engineering Evaluation:
PM Emissions from 1 Cubic Yard of Concrete (from AP-42)

Total PM* equation

Total PM emissions pounds \( \text{yd}^3 \text{of concrete} \) = 0.282(Equation 11.12-1 or Table 11.12-2)

*Total PM= PM,PM10,PM10-2.5,PM2.5

Engineering Evaluation:
Site Specific Emission Factor
Truck Mix and Central Mix Loading*

\[ E \approx k(0.0032) \frac{U^a}{M^b} + c \]

Where:
- \( E \) = Emission factor in lb/ton of cement and cement supplements
- \( k \) = Particle size multiplier (dimensionless)
- \( U \) = Wind speed at the material drop point (mph)
- \( M \) = Minimum moisture (% by weight) of cement and cement supplement
- \( a \), \( b \) = Exponents
- \( c \) = Constant

* (Equation 11.12-1 from Chapter 11.12 of AP-42)

Engineering Evaluation:
Unpaved Roads
(added to emissions from storage piles & represent national average values)

\[ E = k(5.9)(s/12)(S/30)(W/3)^{0.7}((w/4)^{0.5}(365-P)/365)\text{lb/VMT} \]

Where:
- \( E \) = Emission Factor (lb/VMT)
- \( k \) = Particle size multiplier (dimensionless); PM10 \( k=0.36 \)
- \( s \) = Silt content of road surface (%); 12% average
- \( S \) = Mean vehicle speed (mph); 20 mph
- \( W \) = Mean vehicle weight (tons); 20 tons
- \( w \) = Mean number of wheels; 14 wheels
- \( P \) = Number of days with greater than or equal to, 0.01 inches of precipitation per year; 50.7 days
Engineering Evaluation: Emissions from Storage Piles

- AP-42 8.19, Table 8.19.1-1.
- Loading into storage piles, equipment traffic in storage pile area and wind erosion
- Assume:
  1. 3.5 lb/acre/day emission for TSP
  2. 50% or 1.7 lb/acre/day for wind blown dust

Engineering Evaluation: Emissions Characterization

1. Only the transfer points of cement and cement supplement into the storage silos are point source
   - Storage silos abated by fabric filter, baghouse or binvent filter

2. Transfer of sand & aggregate, truck loading, mixer loading, vehicle traffic, and wind erosion from sand and aggregate storage piles
   - Water sprays, enclosures, and baghouse devices and good housekeeping, maintenance and wetting of unpaved surfaces
Engineering Evaluation: Dust Collection Systems

Baghouses are regulated in terms of:
1. Grains/dry standard cubic foot of air emitted or
2. Pounds/ton of aggregate produced
3. Opacity

Engineering Evaluation: Dust Collection Control Efficiency

IDL-ODL/IDL x 100 = CE

Where:
- IDL = inlet dust loading
- ODL = outlet dust loading
- CE = collection efficiency

Units:
- Grains/dry standard cubic foot
Determine compliance with District, Federal regulations & permit conditions
- Fugitive emissions
- Dust Collector emissions
- Visible emission tests
- General maintenance
- Records & logs
- Corrective actions.