MANAGING CCPs RESOURCE of USA

By
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For presentation at the UWM-CBU Workshop on Recycling Opportunities for Fly Ash and Other CCPs in Concrete and Construction Materials

Reduce, reuse, and recycle for sustainable developments.

Minimize use of manufactured materials.

Maximize environmental benefits: clean air, clean water, and resource conservation.
Basic Approach

WASTE is wasted if you waste it, otherwise it is a resource. Resource is wasted if you ignore it and do not conserve it with holistic best practices and reduce societal costs. Resource is for the transformation of people and society.

Focus on turning brown fields into green fields of the 21st Century.
Basic Approach

Recycle. Recycle as is.

Recycle without additional processing, (i.e., without adding any cost to it).
Introduction

• Over 110 million tons of non-hazardous coal combustion products (CCPs) are produced each year in USA (2004). At an average disposal cost of $30. per ton, it would cost 3.3 billion USD to throw it all away.

• CCPs are produced by coal-burning power plants to generate electricity and other industrial plants/boilers to generate steam/energy.

• These by-products generally can be used as a partial substitution of cement and many other everyday construction needs.
Figure 2. Examples of Class C and Class F fly ash.
Under a microscope, fly ash particles look like tiny ball bearings. Hard and round, these particles are so small that in laboratory tests for fineness, the ash can be sifted through screens with more than 100,000 openings per square inch (45 microns). Silica is the primary compound in fly ash.
Fly ash particles (Magnification, 1000 X)
Typical SEM picture of wood ash
B5M Ash
1000X Magnification

KF Ash
100X Magnification
CCPs/CCBs
Coal Combustion Residuals
Coal Fly Ash
Coal Bottom Ash
Slag (Boiler Slag)
Fluidized Gas Desulfurization (FGD)
AFBC/PFBC Ash/Residual
Coal Combustion Products (CCPs)

• Develop recycling technology for high-volume applications of coal combustion products (CCPs) generated by using both conventional and clean-coal technologies.

• Fly ash (Class F, since 1930s, and Class C, since early 1980s), bottom ash, cyclone-boiler slag, and clean-coal ash (since late 1980s, ash derived from SOx control technologies, including FBC and AFBC or PFBC boilers, as well as dry- or wet-FGD materials from SOx/NOx control technologies).
Coal-burning boilers are used in USA for about 55% of total electricity & steam production. Overall recycling rate of all CCPs is about 35% (2004), about 35 million tons.

Cyclone-boiler slag is 100% recycled. High-sulfur coal ashes, such as Class F fly ash and especially clean-coal ashes, are underutilized.

For 2002, in USA, Fluidized Gas Desulphurization (FGD) Gypsum: 11.4 MT (million tonnes) produced, 7.8 MT used (70%); FGD wet-Scrubbers: 16.9 MT, 0.5 MT (3%); FGD Dry-Scrubbers: 0.9 MT, 0.4 MT (45%); and, AFBC/PFBC Ash: 1.2 MT, 0.9 MT (75%). Overall, 30.4 MT produced, 9.6 MT used (32%).
Coal Combustion Products

- Fly ash
- Bottom ash
The precise properties of power plant ash are dependent upon the kind of coal each utility burns and the type of boiler used. Coal mined in the western United States, for example, produces fly ash that has more lime and less silica than ash from eastern coal.
# Chemical Composition

<table>
<thead>
<tr>
<th>Oxides</th>
<th>Sample Name</th>
<th>Cement, Type I</th>
<th>St. Helen Volcanic Ash</th>
<th>VPP Class F Ash</th>
<th>Columbia Unit #1 Fly Ash</th>
<th>P-4 Class C Ash</th>
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<tbody>
<tr>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SiO₂</td>
<td></td>
<td>20.1</td>
<td>62.2</td>
<td>48.2</td>
<td>44.8</td>
<td>32.9</td>
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<tr>
<td>Al₂O₃</td>
<td></td>
<td>4.4</td>
<td>17.6</td>
<td>26.3</td>
<td>22.8</td>
<td>19.4</td>
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<tr>
<td>CaO</td>
<td></td>
<td>57.5</td>
<td>5.7</td>
<td>2.7</td>
<td>17.0</td>
<td>28.9</td>
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<tr>
<td>MgO</td>
<td></td>
<td>1.6</td>
<td>2.2</td>
<td>1.1</td>
<td>5.1</td>
<td>4.8</td>
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<tr>
<td>Fe₂O₃</td>
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<td>2.4</td>
<td>5.6</td>
<td>10.6</td>
<td>4.2</td>
<td>5.4</td>
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<tr>
<td>TiO₂</td>
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<td>0.79</td>
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<td>1.0</td>
<td>1.6</td>
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<td>K₂O</td>
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<td>0.70</td>
<td>1.2</td>
<td>2.3</td>
<td>0.43</td>
<td>0.34</td>
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<tr>
<td>Na₂O</td>
<td></td>
<td>0.22</td>
<td>4.6</td>
<td>1.1</td>
<td>0.29</td>
<td>1.9</td>
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<tr>
<td>Moisture</td>
<td></td>
<td>0.2</td>
<td>0.42</td>
<td>0.39</td>
<td>0.13</td>
<td>0.80</td>
</tr>
<tr>
<td>LOI</td>
<td></td>
<td>1.1</td>
<td>0.60</td>
<td>7.9</td>
<td>0.27</td>
<td>0.65</td>
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</tbody>
</table>
## PLEASANT PRAIRIE FLY ASH

<table>
<thead>
<tr>
<th>Chemical Composition</th>
<th># of Samples</th>
<th>Range</th>
<th>Average</th>
<th>ASTM C-618</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon Oxide (SiO₂)</td>
<td>7</td>
<td>38.5 – 42.8</td>
<td>40.9</td>
<td>--</td>
</tr>
<tr>
<td>Aluminum Oxide (Al₂O₃)</td>
<td>7</td>
<td>14.2 – 17.9</td>
<td>16.1</td>
<td>--</td>
</tr>
<tr>
<td>Iron Oxide (Fe₂O₃)</td>
<td>7</td>
<td>5.6 – 6.6</td>
<td>6.0</td>
<td>--</td>
</tr>
<tr>
<td>Total (SiO₂ + Al₂O₃ + Fe₂O₃)</td>
<td>7</td>
<td>61.1 – 66.3</td>
<td>63.0</td>
<td>50.0 Min.</td>
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<tr>
<td>Sulfur Trioxide (SO₃)</td>
<td>7</td>
<td>2.3 – 3.5</td>
<td>3.0</td>
<td>5.0 Max.</td>
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<tr>
<td>Calcium Oxide (CaO)</td>
<td>7</td>
<td>23.4 – 26.9</td>
<td>25.3</td>
<td>--</td>
</tr>
<tr>
<td>Magnesium Oxide (MgO)</td>
<td>7</td>
<td>4.1 – 4.8</td>
<td>4.6</td>
<td>5.0 Max.</td>
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<tr>
<td>Loss on Ignition</td>
<td>7</td>
<td>0.20 – .64</td>
<td>0.45</td>
<td>6.0 Max.</td>
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<tr>
<td>Available Alkalies as Na₂O</td>
<td>7</td>
<td>0.87 – 1.55</td>
<td>1.2</td>
<td>1.5 Max.</td>
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</tbody>
</table>
## PLEASANT PRAIRIE FLY ASH

<table>
<thead>
<tr>
<th>Physical Tests</th>
<th># of Samples</th>
<th>Range</th>
<th>Average</th>
<th>ASTM C-618</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fineness, % Retained on #325 Wet Sieve</td>
<td>7</td>
<td>15.3 – 23.7</td>
<td>18.8</td>
<td>34.0 Max.</td>
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<tr>
<td>Pozzolanic Activity Index, with Cement @ 28 Days</td>
<td>7</td>
<td>86 – 100</td>
<td>92.4</td>
<td>75.0 Min.</td>
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<tr>
<td>Pozzolanic Activity Index, with Lime @ 7 Days</td>
<td>7</td>
<td>1505 – 2520</td>
<td>1805</td>
<td>800 Min.</td>
</tr>
<tr>
<td>Water Requirement, % of the Control</td>
<td>7</td>
<td>89 – 95</td>
<td>91</td>
<td>105 Max.</td>
</tr>
<tr>
<td>Soundness, Autoclave Expansion (%)</td>
<td>7</td>
<td>0.12 – 0.18</td>
<td>0.15</td>
<td>0.8 Max.</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>7</td>
<td>2.42 – 2.64</td>
<td>2.58</td>
<td>--</td>
</tr>
</tbody>
</table>
Of all the uses for fly ash, the best known are as an additive in portland cement (or, directly in concrete as a SCM) and as a raw-feed material in the production of portland cement. Use of fly ash in concrete increases strength and durability, adding years to the life of the concrete product.
Fly ash is a pozzolan. A pozzolan is an inert siliceous material, which in the presence of moisture will combine with calcium hydroxide, $\text{Ca(OH}_2\text{)}$ to produce a cementitious material with excellent structural properties.
Portland Cement + Water

Free Lime/Ca(OH$_2$)

Fly Ash/Pozzolan

Cementitious Material
COMUNE POZZUOLO MANUTENZIONE STRAORDINARIA MANUFATTO (CHALET) APERTI
SEM Images of BCN60, 7 days
Increased Strength

Fly ash increases the strength of concrete without increasing the costs. The attainment of high compressive strengths, above 6000 psi (41 MPa), enables the concrete producer to command high-strength prices with virtually no increase in cost. He can also offer standard strengths with a reduction in material cost.
Fly ash creates a surface that is more dense, more tightly packed, and more resistant to liquid penetration; primarily due to decreased Ca(OH$_2$). This helps concrete resist water, mild acids, sulfates, and alkalis, without special treatment.
Sharper Detail

Fly ash can be combined with coarse sands to produce sharp detailing, primarily due to increased cohesiveness of the fly ash-concrete mixture. The fineness of fly ash fills forms more completely, creating sharper and more chip resistant edges.
Smoother Surface

Heat is one result of the chemical reaction that creates concrete. The expansion of concrete by this heat, as well as contraction upon cooling, can cause cracks to develop in the surface. Fly ash reduces the heat of hydration, producing a smoother, more attractive surface.
Better Flowability

When added to concrete, fly ash works like millions of ball bearings to reduce friction between particles of concrete and increase fluidity of the concrete, thus improving the concrete construction. The ability to pump concrete many stories high, without double pumping and without building a network of cranes and conveyors, makes the job of pumping set up and removal faster.
Reduces Heat of Hydration

Fly ash reaction generates heat much more slowly than the faster reacting portland cement. Some researchers have concluded that substitution can also slow the hydration of portland cement itself. This combination can minimize heat problems in concrete placements, especially mass concrete.
Improves Workability

The spherical shape and small size of fly ash particles combine to lubricate the concrete mixture.
Reduces Bleeding

The improved workability leads to lower water requirements. This results in less bleeding and consequently more durable surfaces.
Improved Sulfate & Chemical Attack

Use of fly ash in concrete improves resistance to sulfate and acid attack, thus reducing the destructive reaction between some cements and some aggregates.
Resists Sulfate Attack

Fly ash combines with lime (CaOH₂), making it less available to react with sulfates. The resulting cementitious material also blocks concrete bleed channels which limits further entry of the aggressive soluble sulfates. This combination will often improve a concrete’s resistance to sulfate attack.
Resists Effects of Sulfuric Acid

Concrete structures are known to suffer when their wet surfaces are exposed to hydrogen sulfide (e.g., from sewage water). This effect can be almost entirely avoided, by using a concrete mixture containing fly ash.
Many fly ashes react with available alkalies in the concrete making them less available to react with the aggregates.
Fly ash concrete requires less water than plain concrete at any given slump; and, high workability enables placement at lower slumps. Reduction in water content means more strength and less shrinkage, as well as improved durability.
Why Be Interested in Fly Ash?

The answer to this question is short, simple, and clear: a good fly ash, properly used as an ingredient, produces a better concrete at lower cost. Concrete using fly ash is better in many important ways than concrete without fly ash. It provides the contractor and building owner with a more durable product, easier to handle, place, and finish. It helps to increase business and profit for the ready-mixed concrete producer.
BENEFITS of FLY ASH in CONCRETE

- Less Water Demand
- Improved Workability
- Improved Pumpability
- Lower Concrete Cost
BENEFITS of FLY ASH in CONCRETE

- Increased Strength
- Reduced Shrinkage
- Reduced Permeability
- Improved Durability
- Increased Abrasion Resistance
BENEFITS OF CCPs UTILIZATION

- Avoids Disposal Costs
- Conserves Landfill Capacity
- Enhances Environment from Minimizing Disposal
- Virgin and Manufactured Materials Conserved for Higher Priority Use
- Reduces Construction Costs
High-Tech Uses of Fly Ash

- Metal Extraction
- Mineral Extraction
- SO$_2$ Control
- Thermal Insulation
- Heat Resistant Materials
- Rubber Filler
- Plastic Filler
- Metal Filler
- Coagulant
Medium-Tech Uses of Fly Ash

- Cement and Concrete
- Bricks, Blocks, and Paving Stones
- Precast Beams, walls, etc.
- Ceramic Tiles
- Filler in Asphaltic Mixtures
Low-Tech Uses of Fly Ash

- Structural Fills
- Road Base
- Sludge Stabilization
- Land Reclamation
- Grouting
- Soil Amendment
- Mine Backfills
- Coal Mining Operations
Current Uses

- Concrete
- Cement Raw-feed
- Bricks, blocks, and paving stones
- Flowable Slurry and/or SCC
- RCCP
- Blended Cements
- Aggregates from bottom ash and/or slag
Manufacturing of bricks
Air Content Problems

The fineness of fly ash makes it more difficult to develop and hold entrained air.
Low Early Strength

The lb. per lb. substitution mixture proportioning method may result in lower strengths at early ages. Mixture proportioning should take into consideration form removal sequence and anticipated early loading, as well temperature of curing. Lower early strengths can be overcome through the use of appropriate admixtures or other adjustments to the mixture.
To identify and recommend mixture proportions for high-fly ash structural-grade concrete.
Mixture Evaluation

Proposed mixtures should be evaluated for performance prior to construction. Good quality constituents do not always produce a mixture that will perform as desired.
Class C fly ash has higher calcium content than Class F ash and can be used in much greater quantity than the 15 to 20 percent range for Class F fly ash for structural-grade concrete.
Mixture proportions containing fly ash as a replacement for cement on weight basis in amounts of 0, 20, 30, 40, 50 and 60% were developed for three strength levels of 3000, 4000, and 5000 psi (21, 28, and 34 MPa).
Concrete with and without air entrainment was produced in which fly ash was substituted for cement in quantities of up to 70% of total cement replacement.
1. Two brands of Type I cement
2. Two sources of aggregates
3. Slump: 4” ± 1” (100 ± 25 mm)
4. Air entrained and non-air entrained
5. Air entrainment: 5.5% ± 1%
FRESH CONCRETE TESTS PERFORMED

1. Temperature
2. Slump
3. Air Content
4. Density
5. Workability noted
### CONCRETE MIXTURE AND TEST DATA

**5000 psi (34 MPa) SPECIFIED STRENGTH**

**P4 ASH – STRUCTURAL CONCRETE**

**CONCRETE SUPPLIER:** Central Ready Mixed Concrete

<table>
<thead>
<tr>
<th>Mixture No.</th>
<th>P4-13</th>
<th>P4-14</th>
<th>P4-15</th>
<th>P4-16</th>
<th>P4-17</th>
<th>P4-18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specified Design Strength, psi</td>
<td>5000</td>
<td>5000</td>
<td>5000</td>
<td>5000</td>
<td>5000</td>
<td>5000</td>
</tr>
<tr>
<td>Cement, lbs</td>
<td>611</td>
<td>490</td>
<td>428</td>
<td>367</td>
<td>305</td>
<td>245</td>
</tr>
<tr>
<td>Fly Ash, lbs</td>
<td>0</td>
<td>145</td>
<td>220</td>
<td>295</td>
<td>382</td>
<td>441</td>
</tr>
<tr>
<td>Water, lbs</td>
<td>290</td>
<td>291</td>
<td>289</td>
<td>270</td>
<td>278</td>
<td>268</td>
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<tr>
<td>Sand, SSD, lbs</td>
<td>1450</td>
<td>1450</td>
<td>1450</td>
<td>1450</td>
<td>1450</td>
<td>1450</td>
</tr>
<tr>
<td>¾” Aggregates SSD, lbs</td>
<td>1810</td>
<td>1810</td>
<td>1810</td>
<td>1820</td>
<td>1810</td>
<td>1810</td>
</tr>
</tbody>
</table>
As the amount of fly ash increased, the water demand decreased while maintaining the same slump (4” ± 1”).
## CONCRETE STRENGTH TEST DATA

5000 psi (34 MPa) SPECIFIED STRENGTH

AVERAGE COMpressive STRENGTH, PSI

<table>
<thead>
<tr>
<th>Test Age, Days</th>
<th>Mixture No.</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>P4-14</td>
<td>P4-15</td>
<td>P4-16</td>
<td>P4-17</td>
<td>P4-18</td>
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<tr>
<td>1*</td>
<td>2519</td>
<td>2448</td>
<td>2044</td>
<td>1942</td>
<td>1230</td>
<td>1336</td>
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<tr>
<td>3</td>
<td>2904</td>
<td>2987</td>
<td>2591</td>
<td>2390</td>
<td>314**</td>
<td>116**</td>
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<tr>
<td>7</td>
<td>3902</td>
<td>4168</td>
<td>3854</td>
<td>3892</td>
<td>3392</td>
<td>205**</td>
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<tr>
<td>28</td>
<td>5300</td>
<td>6353</td>
<td>5993</td>
<td>6864</td>
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<td>91</td>
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<td>7209</td>
<td>7519</td>
<td>8004</td>
<td>9012</td>
<td>8493</td>
</tr>
</tbody>
</table>

*AFTER ACCELERATED CURING, USING BOILING WATER METHOD.

**CYLINDERS WERE “GREEN” WHEN TESTED.
## CONCRETE STRENGTH TEST DATA –
### 5000 psi (34 MPa) STRENGTH, PLANT NO.2

<table>
<thead>
<tr>
<th>Mixture No.</th>
<th>Fly Ash, %</th>
<th>Compressive Strength, psi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>19 hrs</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>2720</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>2790</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>2920</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>3020</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>3120</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>3220</td>
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</table>

<table>
<thead>
<tr>
<th>Test Age, Days</th>
<th>19 hrs</th>
<th>22 hrs</th>
<th>3</th>
<th>3</th>
<th>7</th>
<th>7</th>
<th>14</th>
<th>14</th>
<th>28</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave.</td>
<td>2720</td>
<td>2950</td>
<td>3040</td>
<td>3710</td>
<td>3800</td>
<td>3860</td>
<td>3640</td>
<td>4070</td>
<td>4350</td>
<td>4740</td>
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<tr>
<td>Ave.</td>
<td>2790</td>
<td>3180</td>
<td>3430</td>
<td>3890</td>
<td>4195</td>
<td>5110</td>
<td>4100</td>
<td>4740</td>
<td>4210</td>
<td>4774</td>
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<tr>
<td>Ave.</td>
<td>2920</td>
<td>3490</td>
<td>3430</td>
<td>4090</td>
<td>4905</td>
<td>5210</td>
<td>4100</td>
<td>5910</td>
<td>4630</td>
<td>5595</td>
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<tr>
<td>Ave.</td>
<td>3020</td>
<td>3750</td>
<td>4100</td>
<td>4880</td>
<td>5610</td>
<td>6120</td>
<td>5450</td>
<td>6650</td>
<td>6580</td>
<td>6300</td>
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<tr>
<td>Ave.</td>
<td>3120</td>
<td>4140</td>
<td>4900</td>
<td>5130</td>
<td>6120</td>
<td>6315</td>
<td>5520</td>
<td>6615</td>
<td>6440</td>
<td>6830</td>
</tr>
<tr>
<td>Ave.</td>
<td>3220</td>
<td>4170</td>
<td>5190</td>
<td>5060</td>
<td>6175</td>
<td>7040</td>
<td>5910</td>
<td>6175</td>
<td>8450</td>
<td>7710</td>
</tr>
</tbody>
</table>

Center for By-Products Utilization
Project experience with high-fly ash content concrete
PROJECT 1: MAY 1984

5” thick slab x 15’ x 20’ = 5 yd³,
70% fly ash replaced for cement.
Frontier Ready Mix Loading Area
Slinger, Wisconsin.
PROJECT 2: SEPTEMBER 1984

24’ wide truck access road.
10” thick x 1400 ft long, = 1000 yd³, 70% fly ash replaced for cement.
Pleasant Prairie Power Plant
Wisconsin, USA.
COMPRESSIVE STRENGTHS

7-day = 1150 PSI
28-day = 2200 PSI
56-day = 3500 PSI
Chloride-Ion Penetration for Core Specimens
## Chloride-Ion Penetration for Concrete Cores

<table>
<thead>
<tr>
<th>ASTM C1202 Charge Passed (coulombs)</th>
<th>ASTM C1202 Chloride ion Penetrability</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;4000</td>
<td>High</td>
</tr>
<tr>
<td>2,000-4,000</td>
<td>Moderate</td>
</tr>
<tr>
<td>1,000-2,000</td>
<td>Low</td>
</tr>
<tr>
<td>100-1,000</td>
<td>Very Low</td>
</tr>
<tr>
<td>&lt;100</td>
<td>Negligible</td>
</tr>
</tbody>
</table>
Fly ash is used in large quantities as a fine aggregate in RCCP, and up to 50% of total cementitious materials.
ECONOMICAL
SELF-CONSOLIDATING
CONCRETE
Slump-Flow Test
DEVELOPMENT OF SCC

Concerns regarding the homogeneity and compaction of concrete within intricate or heavily-reinforced structures, and to improve overall durability quality of concrete, brought the development of SCC in the late-1980s in Japan, and the spread in the mid-1990s to Europe (especially France).

Flowable SCC/Slurry has been used in Wisconsin for the last 20 years or so.
DISADVANTAGES OF USING SCC

- More care required in selection of materials and mixture proportioning
- QC and QA are Important
- Higher liquid admixtures cost
- Requires tighter formwork to prevent leakage
- Higher lateral pressure on formwork
APPLICATIONS OF SCC

• Precast concrete products
  – Bridge components
  – Double Ts
  – Pipes
• Footings
• Columns
• Walls
• Unfinished decorative-walls
MANUFACTURE OF BLENDED CEMENTS

Raw Material in Production of Cement Clinker
Interground with Clinker
Blended with Cement
WATER POLLUTION CONTROL

a) Neutralization of Acidic water
b) Phosphorus Removal from Wastewater
c) Sludge Dewatering
d) Sorbent for Organics
e) Sealing of Contaminated Sediments
Cenospheres are used in cast-metal products as a filler. They improve damping and abrasion resistance of the material.
OTHER FILLER
APPLICATIONS
Asphalt Roofing Shingles
Joint Compound
Carpet Backing
Vinyl Flooring
Industrial Coatings, etc.
Use of CCPs for Lightweight Aggregates

a) Unfired (Cold Bonded Process) 
b) Sintered (Fired) Aggregates
Concrete with Lightweight Aggregates – fly ash used as a pumping aid.
USES of CCPs

TECHNICALLY PROVEN.
COMMERCIAL EFFECTIVE.
ENVIRONMENTALLY SOUND.
Energy Conservation

Nearly six million BTUs are needed to produce one ton of portland cement. Use of fly ash saves that energy and conserves our dwindling resources. Also, portland cement produces one ton of GHGs per ton of cement.
La Bella Terra – The Beautiful Earth
Thank you very much for your interest.
Aabhar Tamaro, Afcharisto Poly, Arigatou Gozaimasu, Grazie Molte, Maraming Salamat, Merci Beaucoup, Muchas Gracias, Muito Obrigado, Salamat, Shukriya, Spasibo, Thank you, Toda Raba.