Concrete Applications Using High Carbon Fly Ash from the TOXECON™ Baghouse

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NASDAQ:ADES

A Leader in Clean Coal Technology

TOXECON™ - 270 MW Demonstration

- Presque Isle Power Plant, Marquette MI
  - Units 7-9
  - PRB Coals
- $53.3M
  - $24.9M DOE
  - $28.5M We Energies
- Project Goals
  - 90% Hg - Continuous
  - 70% SO2 - Short- term
  - 30% NOX – Short-term
  - Improved Ash Management
  - Mercury Recovery

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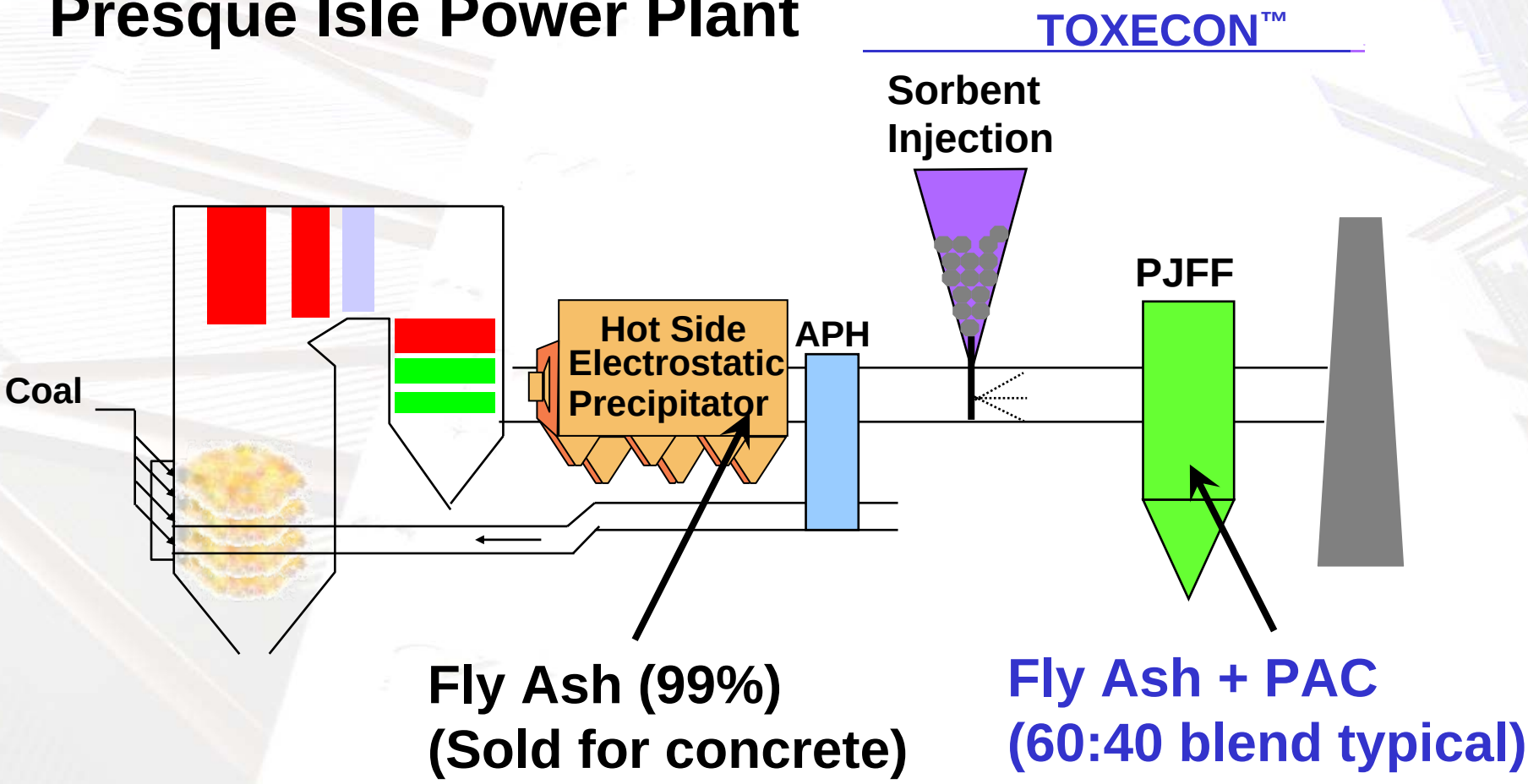
TOXECON™ Configuration

Presque Isle Power Plant



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Ash/Mercury Management Evaluation

- Goal is to eliminate PAC/ash disposal in landfill
- Options evaluated on the Clean Coal Project
  - Thermal Desorption
    - Mercury removal using microwave energy
      - Michigan Tech University and UP Steel
    - Mercury removal using thermal processing, end product is fertilizer (“fly ash to fertilizer”)
      - United Environmental & Energy
  - Use PAC/ash in concrete
    - High carbon applications
    - Low carbon (<5% LOI) applications

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TOXECON™ Baghouse Ash

- Typical LOI is 40% during steady-state operation
- Mercury content is 65-75 µg/g
- PRB ash from this site is is cementitious and pozzolanic
  - These ashes harden when wetted
- Ash from this site is a Class C fly ash and meets ASTM C618 limitation of <6% LOI (<5% LOI for AASHTO) for use in structural concrete products

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Beneficial Use of Ash in Concrete

- In 2007, 13.6 million tons of fly ash was used in concrete/concrete products/grout manufacturing (ACAA, 2008)
- Fly ash is commonly used as a partial replacement for portland cement
- Fly ash improves workability, reduces water demand, and lowers the heat of hydration
- Fly ash also increases strength, reduces corrosion of reinforcing steel, increases sulfate resistance and reduces alkali-aggregate reaction
- As a replacement for cement, fly ash reduces the carbon footprint of concrete. For every one ton of cement reduction by use of fly ash, there is a corresponding 1 ton reduction in CO_2 emissions.

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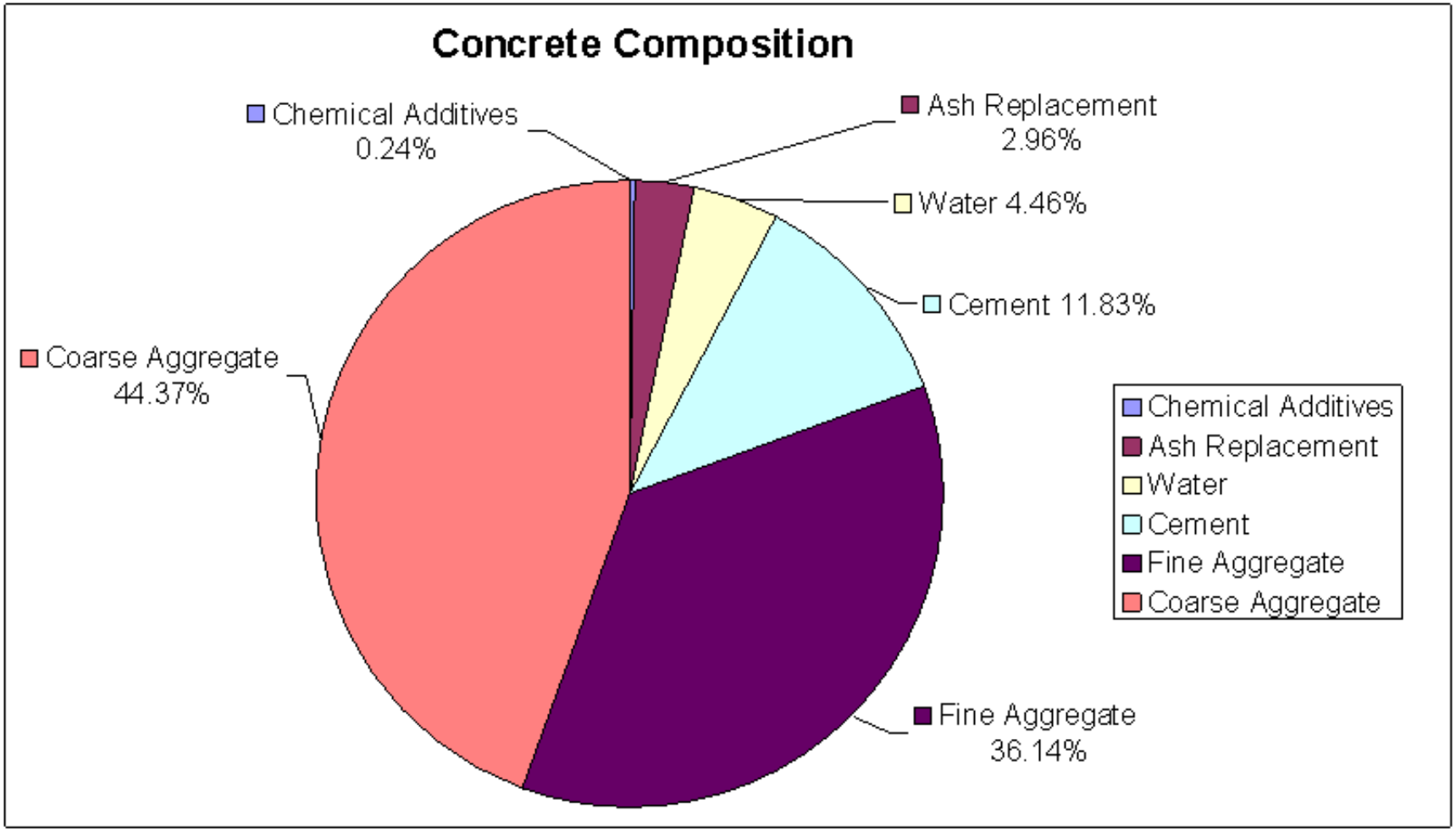
What's in Concrete



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What's in Concrete

- Aggregate (gravel & sand)
  - Majority of strength
- Water Cement Ratio
  - inversely proportional to strength
- Chemical Admixtures
  - Air Entrainment
  - Water Reducers
  - Set Modifiers
- Liquid Air Entrainment Additives (AEAs)
  - Air voids provide freeze/thaw durability
  - Created during mixing
  - Susceptible to carbon
- Miracon™ air entrainment (AEA)
  - Foam added to concrete at the end of mixing
  - Resistant to carbon

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Miracon ToughAir™

- A new generation of air entrainment (AEA), produced through an advanced mechanical system, using a polymer-based chemical formulation, suitable for use in all types of concrete products
- This technology is suitable for use with all types of fly ash and aggregates

Lab-Scale Tests – ADA ES

- 1.3 cu ft batches of concrete
- 20% replacement of cement with ash
  - Ash replacement was calculated to adjust for LOI, increasing actual ash mixture (Class C plus PAC)
- Variables:
  - Total cementitious material (7-sack and 6-sack mixes)
  - Water/cement ratio
  - LOI
  - Admixtures
  - AEAs

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Lab-Scale Tests – ADA ES

- Tests with AEAs reflected the foam index values and sensitivity to carbon
- Laboratory evaluation of concrete mixtures using the high PAC TOXECON ash at 0.5, 2, 5, and 30% LOI with Miracon air entrainment
- Tests include
  - Compressive strength
  - Petrographic analysis (hardened air void)
    - Ongoing

Lab-Scale Tests - Miracon™

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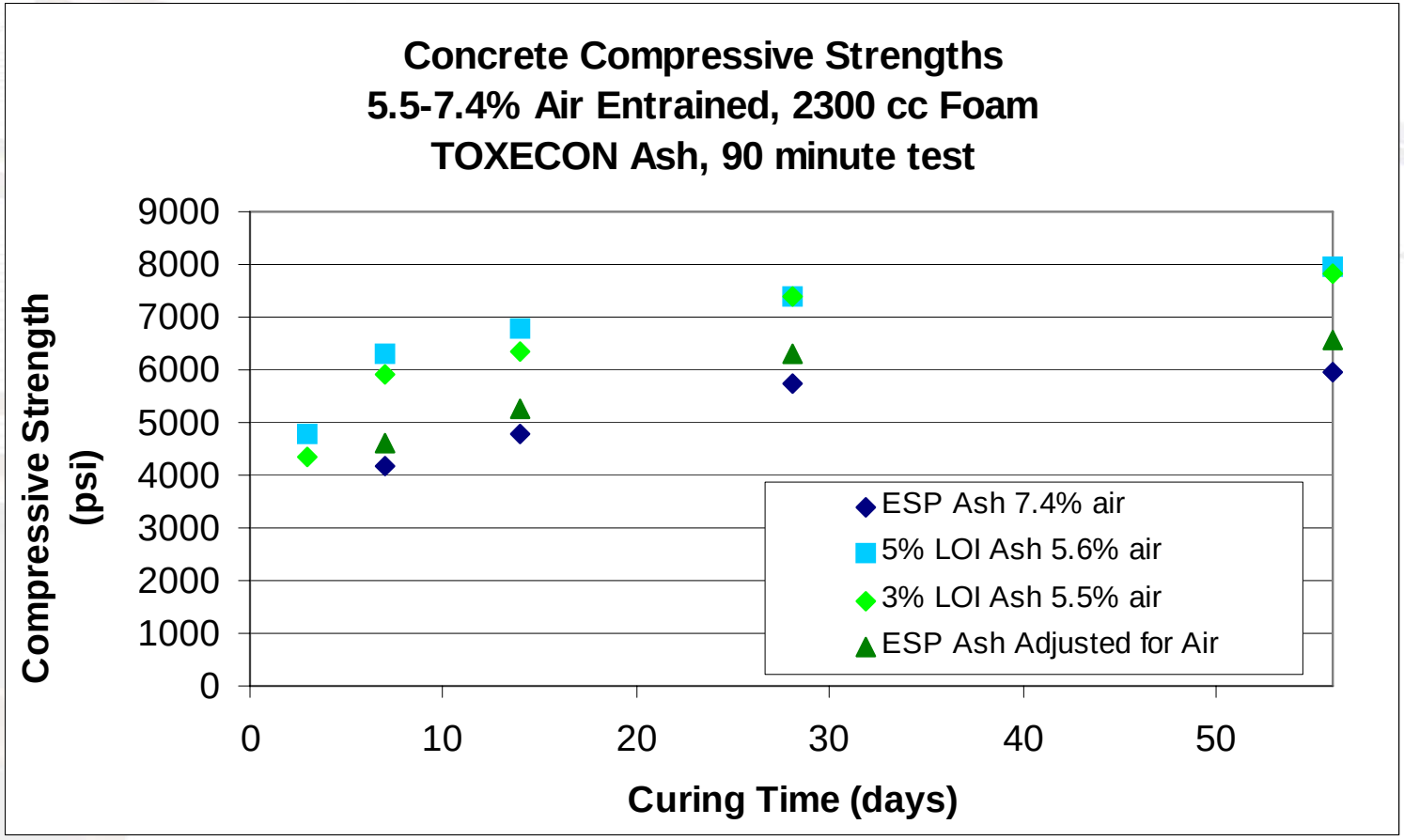
Lab-Scale Test Results
6-sack Mix



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Lab-Scale Test Results

- Hardened air void test (petrographic) showed that the ESP ash control (0.7% LOI) and the 5% LOI passed for air content and spacing factor
- This test indicates that these samples would show good freeze/thaw durability
- Freeze/thaw durability is one of the most important criteria for predicting long-term performance

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Field Test – Sky Ute

- Several 4-yard batches of concrete with LOI varying from 0.7-5% were made at Sky Ute Sand & Gravel with the Miracon air entrainment process
- TOXECON™ ash was the starting material

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Field Test Results – Sky Ute

- 2% LOI blended ash from TOXECON™
- Strength tests ongoing
- Excellent 14-day strength at 5073 psi
- Hardened air void test (petrographic) showed

Field Test - PIPP

- A test pad 30’ x 60’ will be poured at PIPP in the spring using TOXECON ash and the Miracon air entrainment process
- Ongoing testing at varying LOI levels up to 40% with Miracon air entrainment to determine final formulation

Future Work

- Continue evaluation of impact of ash composition and local aggregates on behavior of entrained air
- Looking for additional test sites and materials

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Ash Management Evaluation

- Goal is to eliminate PAC/ash disposal in landfill
- Options being evaluated
  - Reprocess PAC for re-injection
  - Reprocess PAC for alternative product (fertilizer)
  - Use PAC/ash in concrete

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Reprocessing PAC

- Michigan Tech University
  - Microwave energy
  - Successful lab-scale demo
    - Removal of mercury
    - PAC/ash sorbent screening test
- United Environment & Energy
  - Thermal energy
  - Successful pilot-scale demo
    - Removal of mercury
    - Conversion to fertilizer
    - Greenhouse testing

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PAC/Ash Use in Concrete

- Dallas based Miracon Technologies has developed a low-cost air entraining process that is minimally affected by activated carbon content
- Laboratory evaluation of concrete mixtures using the high PAC TOXECON ash at varying LOI levels
- Tests include
  - Compressive strength
  - Hardened air void analysis
  - Chloride permeability
- Lab and full scale tests were performed at Sky Ute Sand & Gravel in Farmington NM using the new air entraining process
- Based on promising lab- and full-scale results, a test pad 30’ x 60’ will be poured at PIPP using TOXECON ash and the new air entraining process

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