Building Product Ecosystems...

Multi-disciplinary Open Innovation to Evolve Systemic Health

Transparent Lifecycle and Health Data
EWG Body Burden Study: The Pollution in Newborns, 2005

**Mercury (Hg)** - tested for 1, found 1

**Polyaromatic hydrocarbons (PAHs)** - tested for 10, found 9
Pollutants from burning gasoline and garbage. Linked to cancer. Accumulates in food chain.

**Polybrominated dibenzodioxins and furans (PBDD/F)** - tested for 12, found 7
Contaminants in brominated flame retardants. Pollutants and byproducts from plastic production and incineration. Accumulate in food chain. Toxic to developing endocrine (hormone) system.

**Perfluorinated chemicals (PFCs)** - tested for 12, found 9
Active ingredients or breakdown products of Teflon, Scotchgard, fabric and carpet protectors, food wrap coatings. Global contaminants. Accumulate in the environment and the food chain. Linked to cancer, birth defects, and more.

**Polychlorinated dibenzodioxins and furans (PCDD/F)** - tested for 17, found 11
Pollutants, by-products of PVC production, industrial bleaching, and incineration. Cause cancer in humans. Persist for decades in the environment. Very toxic to developing endocrine (hormone) system.

**Organochlorine pesticides (OCs)** - tested for 28, found 21
DDT; chlordane and other pesticides. Largely banned in the U.S. Persist for decades in the environment. Accumulate up the food chain, to man. Cause cancer and numerous reproductive effects.

**Polybrominated diphenyl ethers (PBDEs)** - tested for 46, found 32
Flame retardant in furniture foam, computers, and televisions. Accumulates in the food chain and human tissues. Adversely affects brain development and the thyroid.

**Polychlorinated Naphthalenes (PCNs)** - tested for 70, found 50

**Polychlorinated biphenyls (PCBs)** - tested for 209, found 147

Source: Chemical analyses of 10 umbilical cord blood samples were conducted by AXYS Analytical Services (Sydney, BC) and Flett Research Ltd. (Winnipeg, MB).
80% [emissions reduction] by 2050
ZERO [waste] by 2030
Building Product Ecosystems | Working Groups

**Evolving Wallboard Systems**
Optimizing wallboard cycles, to establish closed-loop wallboard post-consumer recycling process and infrastructure.

**Flame Retardants & Codes**
Evaluating appropriate Code requirements for building products and assemblies to best balance fire safety with minimized health impacts from flame retardant use.

**Glass in Concrete**

**Transparency.**
Collaboration between Buyers, Makers, Designers, Recyclers, Policy, + Academia.

**Pragmatic Application for Real Project Challenges.**
Evolving the Holistic Health of Manufacturing + Recycling.

Implementing Closed-Loop Post-Consumer Gypsum Wallboard Recycling
Why Closed Loop Gypsum Wallboard Recycling?

- 9 Million tons drywall waste generated each year. Only 400,000 tons currently recycled.
- Avoid hydrogen sulfide emissions from wallboard in anaerobic landfill conditions (exacerbates asthma)
- Minimize generation of methane GHG resulting from paper facing interaction with bacteria in landfill environment.
- Minimize gypsum fines contamination (via SO2) of low-carbon C+D wood waste biomass.
- Minimize Mining of land for Natural Gypsum
- Mercury (Hg) - Content, Emissions, Effluent from coal-fired power plants

Closing the Gypsum Wallboard Recycling Loop

- Synthetic Post-Industrial Gypsum
- Natural Mined Gypsum
- Wallboard Manufacturer
- Construction Site Source Separation
- Hauler/Rough Sorter
- Landfill
- Animal Bedding
- Ceiling Tile
- Paper
- Soil Amendment
- Sorted Post-Consumer Recycled Gypsum
Regional Wallboard Supply/Processing

Comingling in Packer Truck = Less Recyclable Gypsum
Pilot Source Separation Sites

Job Site Logistics
Job Site Logistics

Click to view video of:
job site workers talking about wallboard source separation logistics
Evolving Wallboard Systems Pilots
Source-Separated Hauling to Transfer Station
Cardella – North Bergen, NJ

Evolving Wallboard Systems Pilots
Gypsum + Paper Facing Separation, Processing
USA Gypsum | Denver, PA
Evolving Wallboard Systems Pilots
Manufacturing w/ Post-Consumer Gypsum
USG | Washingtonville, PA

Research Goals

- Identify contaminants, levels
- Understand release + exposure in harvest, manufacture, processing, transportation, use, and disposal
- Establish industry-recognized transparent, consistent quality control standards + methods for remanufacturing gypsum wallboard
Standardization for Streamlined Implementation

Designation: X XXXX-XX

Standard Practice for
The Selection of Post-Consumer Gypsum Board for Closed-Loop Recycling

This standard is issued under the joint designation X XXXX; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard includes the physical condition and compositional criteria for selecting post-consumer gypsum board for use in manufacturing new board product.

1.2 This standard only applies to recycled material for use in interior gypsum board and not in exterior use panel products or in any specialty product such as type X, type C, impact resistant or mold and mildew resistant products.

1.3 This standard does not dictate the minimum amount of recycled board a manufacturer is to use in producing new board, but does define a minimum amount of recycled material in order

Summary

Issue:
While most waste from construction sites can be collected in dumpsters and then separated and recycled off-site, certain materials become damaged when co-mingled. They cannot be reused or recycled unless they are separated at the construction site.

Recommendation:
Require ceiling tiles, carpeting, new gypsum wallboard scrap, and large-dimension lumber to be sorted on-site and reused or recycled. Also, require construction-waste management plans for large projects.

Proposed Legislation, Rule, or Study

Amendments to the New York City Building Code:

1. Add the following definitions to Section 3302.1:

CONSTRUCTION WASTE MANAGEMENT PLAN. A plan outlining procedures for the reuse, including resale, or recycling of recoverable waste materials generated during construction and demolition.
Landfill Tipping

Implementing Closed-Loop Post-Consumer Gypsum Wallboard Recycling
Recycled Glass Pozzolan Replacing Cement in Concrete

- 90 million tons produced in the US / year.*
- 3 million tons used in NY / year.*
- 9.5 million tons used in CA/year.*
- Per EPA, 1 ton of production results in 1 ton CO2.
- Per EPA, annual Cement impact = GHG emissions of 16 million cars.

* Source: Per USGS Cement Statistics and Information
NYC Glass in Concrete Working Group

Supplementary Cementitious Materials [SCMs]

**SCMs** Replace X% of cement in concrete, reducing CO2 emissions from cement production. SCMs can also improve performance.

- **Fly Ash** | byproduct, coal-fired power
- **Slag** | byproduct, blast furnaces
- **Silica Fume** | byproduct, silicon manufacture
- **Natural Pozzolans** | calcined clays/shales, glass

Source: From PCA Design Manual Chap 3.
Inconsistent Fly Ash Supply

Scheduled electricity generation capacity additions and retirements in 2015
megawatts

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<td>Jan</td>
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<td>Mar</td>
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<td>Sep</td>
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<td>Oct</td>
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</tr>
<tr>
<td>Nov</td>
<td>-12,000</td>
</tr>
<tr>
<td>Dec</td>
<td>-13,000</td>
</tr>
</tbody>
</table>

annual net change:
- wind (9,811 MW)
- natural gas (4,318 MW)
- solar (2,236 MW)
- nuclear (1,122 MW)
- other renewables (471 MW)
- petroleum and other (-900 MW)
- coal (-12,922 MW)

Source: U.S. Energy Information Administration, Electric Power Monthly
Note: Other renewables include hydroelectric, biomass/wood, and geothermal.

Inconsistent Fly Ash Supply

Coal-fired generator retirements primarily due to EPA’s Mercury and Air Toxics Standards (MATS).

Inconsistent Regional Blast Furnace Slag Supply

“The availability of blast furnace slag is becoming problematic in the U.S. because of:

● closure of a number of active U.S. blast furnaces in recent years,
● lack of construction of new furnaces, and
● depletion of old slag piles.”

11.8 million tons of post-consumer glass is generated in the U.S. annually. …only 28% is recycled.*

135,000 tons of post-consumer glass is generated in NYC annually… 60% is recycled.

*http://www.epa.gov/osw/conserve/materials/glass.htm

Sims Municipal Recycling Plant

- Located in Jersey City
- 8,000-10,000 tons glass per month
- Screens, Magnets, Eddy Current, Crushers
- Clear glass separation with optical sorters
- Removal of heat-resistant and leaded glass
Sims NYC Recycling Market
[current]

~1,200 tons/month Clear Glass sold to Container Market

~5,000 tons/month Mixed Color Glass crushed for 3/8" Recycled Glass Aggregate [RGA] Market

Recycled Glass Aggregate (RGA)

- **Pros**: Large bulk projects, modest processing costs, competitive with alternative aggregates
- **Cons**: Unpredictable demand, seasonality, low value

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<tr>
<th>Average</th>
<th>% Finer</th>
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<tr>
<td>1/2&quot;</td>
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<tr>
<td>#200</td>
<td>6</td>
</tr>
<tr>
<td>LOI</td>
<td>2-3%</td>
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</table>

Structural Fill Blend, Brooklyn Pier
Clean Fill, Site Remediation Perth Amboy, NJ
Filtration Media, DOT Roadwork, Queens
NYC Glass in Concrete Supply Chain

- **NYC Residential Curbside Recycling**
  - Un-Recycled Glass 4,500 tons/month
- **Material Recovery Facilities (MRFs)**
  - Sorted Clear Glass to new glass production ~1,200 tons/month
- **Mixed Colored Glass 5,000 tons/month**
- **Recycled Glass Aggregate (RGA)**
  - Roadbed Aggregate
  - Stormwater Filtration
  - Drainage Pipe Bedding
  - Clean Fill/Blends
- **Concrete Batch Plant**
- **Concrete Depot / Distributor**
  - Clean, Ground Glass Pozzolan
- **Glass Processing Facility**
  - Glass Pozzolan
  - Portland Cement
  - Fly ash
  - Slag
  - Silica Fume
- **Landfill**
- **Cast-in Place at Construction Site**
  - Ready Mix Concrete
- **NYC Residential Curbside Recycling**
  - Mixed Colored Glass 5,000 tons/month

Pozzotive Precedent

- Pozzotive Block & Masonry Supply, LLC
Ground Glass meeting Code

Code Review:
ACI 318 Building Code Requirements, Chapter 3 allows use of SCMs that conform to the following ASTMs:

- **ASTM C989 (AASHTO M302)** - Ground granulated iron blast-furnace slags; Grade 80, 100, 120

- **ASTM C618 (AASHTO M295)** - Fly ash and natural pozzolans
  - Class N – Natural pozzolans
  - Class F – Fly ash with pozzolanic properties
  - Class C – Fly ash with pozzolanic and cementitious properties

- **ASTM C1240** - Silica fume

Batch Plant Operation, Silos
Halletts Point | Concrete Specification

2.4 CONCRETE MATERIALS

A. Portland cement: ASTM C 150, Type I or II, ASTM C 1157, Type GH or LH. Concrete of 8,000 psi @ 28 days or higher strength requires the use of one brand of cement as approved by the Engineer.

B. Supplementary Cementitious Materials:

1. Slag: ASTM C989, Grade 100 or 120, may be used up to a maximum of 35% of the total cement content.

2. Pozzolans: ASTM C 618 -08 Class N, may be used up to a maximum of 35% of the total cement content

3. At no point shall the sum of the Slag and Pozzolan quantities exceed 35% of the total cement content

4. The exact percentages used shall be based on a successful test placement onsite.

This project is being used as a prototype to introduce the use of Post-Consumer Powdered Glass Pozzolans as a replacement to the above-specified Slag. All things being equal, physical properties, chemical properties and economics, the use of powdered glass pozzolans in lieu of Slag will be given preferential treatment.

Halletts Point | Technical Performance Testing

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<tr>
<th>Mix</th>
<th>Source</th>
<th>6000psi w/pozz</th>
<th>8000psi w/pozz</th>
<th>10000psi w/pozz</th>
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<td>7/1/2018</td>
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<tr>
<td>Cement (lbs)</td>
<td>Easoe Cement - Type III</td>
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<td>508</td>
<td>563</td>
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<tr>
<td>Glass Pozzolan</td>
<td>Pozzolan</td>
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<td>270</td>
<td>297</td>
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<td>Sand (lbs)</td>
<td>Roanoke Sand &amp; Gravel</td>
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<td>Stone #1 (lbs)</td>
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<td>Admixture 1 (lbs)</td>
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<tr>
<td>Admixture 2 (car)</td>
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<tr>
<td>Spread (in)</td>
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<td>n/a</td>
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<tr>
<td>As (%)</td>
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<td>5960</td>
<td>6930</td>
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FUTURE TECH CONSULTANTS
Halletts Point | Technical Performance Testing

| 7 day average | 8630 | 7830 | 9307 |
| 10 day results | 6470 | 9690 | 10870 |
| 10 day average | 6665 | 9708 | 11370 |
| 20 day results | 7690 | 10910 | 12260 |
| 20 day average | 7810 | 11190 | 12110 |
| 28 day results | 7833 | 11223 | 12183 |
| 28 day Length change | 6.43 | 6.91 | 6.59 |
| 56 day results | 8670 | 12400 | 13880 |
| 56 day average | 8860 | 12650 | 13910 |
| MOD E | 6.89 | 7.13 | 7.12 |
| Permeability | 2099 | 2861 | 2839 |
| 91 day results | 9000 | 13630 | 14550 |
| 91 day average | 9220 | 13710 | 14430 |
| MOD E | 6.97 | 6.49 | 7.66 |
| Permeability | 579 | 200 | 128 |

Halletts Point | Ground Glass Pozzolan Concrete Mock-up