Solutions for Waste in the Foundry Sector

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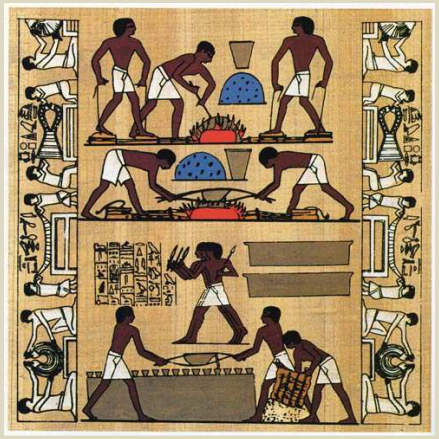
History of Metal Casting



Worldwide Importance of Foundries

Many Hurdles

- Lackluster economy
- Cheaper imports
- Competitive market
- Shrinking customer base
- Infrastructure upgrades
- Burdensome regulations
- Waste disposal issues

What Can Foundries Do?

- Nothing
- Close
- Sell
- Take action!!!

Foundry = Recycling ≈ Green Industry

Brass

Iron

Aluminum

Copper

Steel

Other Alloys

Metalcasting Waste Products

Molding sand

Core sand

Slag

Baghouse dust

Furnace refractory

Broken cores

Shotblast fines

Graphite electrodes

Fate of Most Foundry Wastes




Tandil, Argentina

Definition of Beneficial Use

"Any further use other than the original use of a discarded material or byproduct that would otherwise become waste"

Winkler and Bol'shakov, 2000

Beneficial Use ≠ Recycling or Reuse

Why Beneficially Use Foundry Wastes?

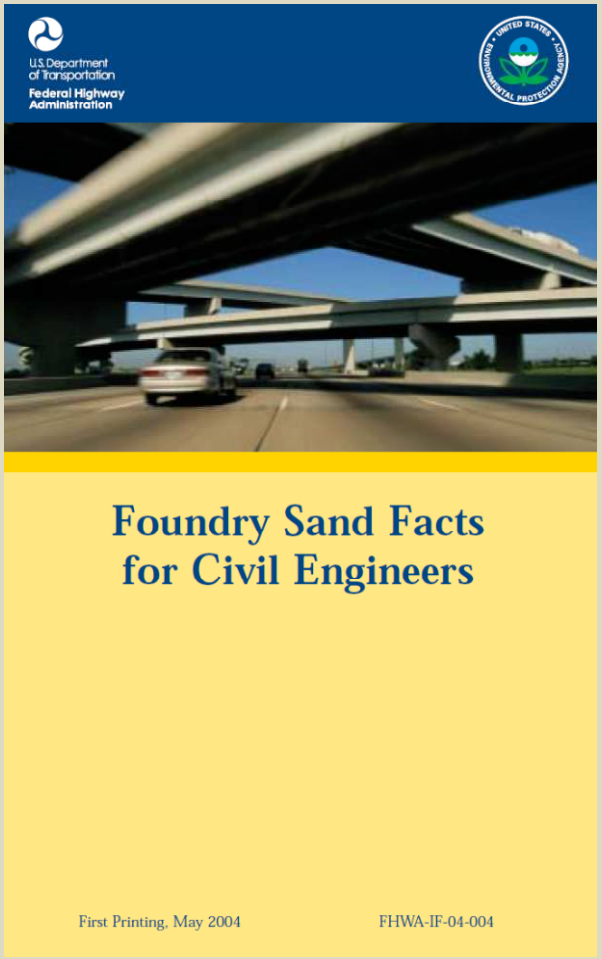
- Conserve raw materials and energy
- Minimize pollution of soil, water, and air resources
- Turn waste into a valuable resource
- Reduce disposal costs
- Improve competiveness of foundries

Waste Foundry Sands

Largest waste from the Foundry Industry

- Asphalt
- Concrete
- Construction fill
- Flowable fill (CLSM)
- Grouts and mortars
- Highway embankments
- Landfill liners and covers
- Paver stones and bricks
- Pipe bedding
- Potting and specialty soils
- Road bases

U.S. Department of Transportation



Technical guidance document for the beneficial use of waste foundry sands in civil engineering applications

http://isddc.dot.gov/OLPFiles/FHWA/011435.pdf

Defining WFS For Beneficial Use Applications

- WFS = Clay or chemically bonded molding/core sands
- Segregate sands from other waste materials (e.g. core butts, metal fragments, debris)
- Quality and consistency are very important (Quantity too!)

Agricultural and Horticultural Applications

- Direct land application (improve soil texture)
- Potting soils
- Topsoil (landscaping and turf grass)

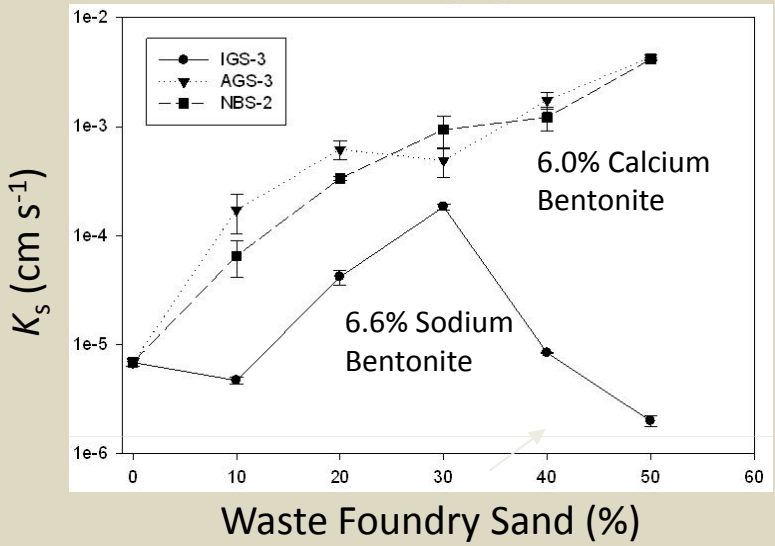
What are the Risks from Foundry Sands?

- “Cleaner Than Dirt” campaign
- Metal concentrations similar to levels in native soils
- Low dioxin, PAH, and phenolic concentrations
- Conducted foundry sand risk assessment with U.S. EPA (home gardener scenario)
- Most ferrous and aluminum foundry sands are safe for use in soil-related applications

Metals in Foundry Sands (mg kg^{-1})

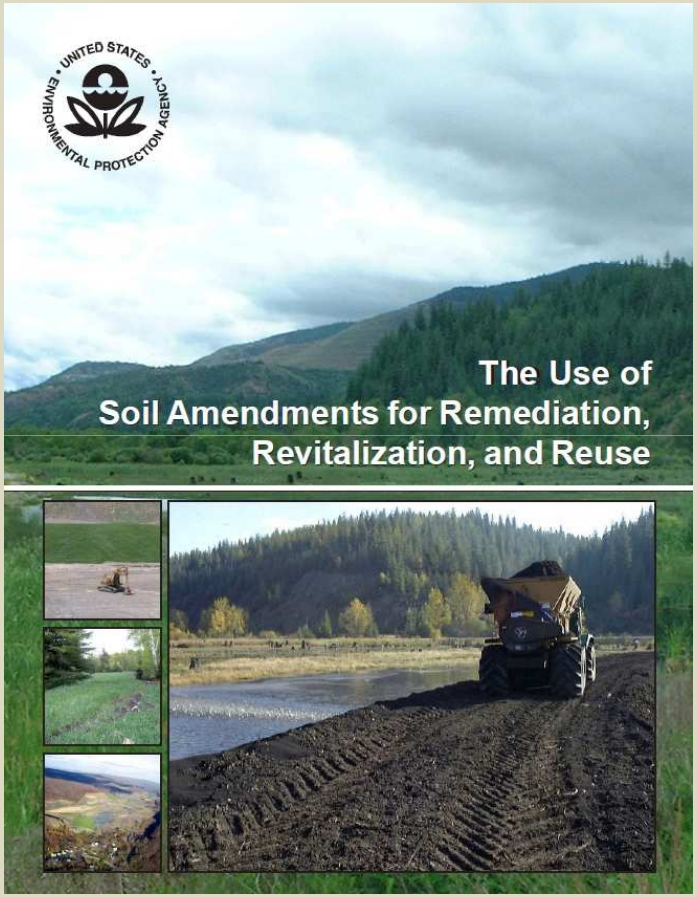
Element	Waste Sands		North American Soils	
	Median	Max	Median	Max
As	1.1	7.8	5	18
Ba	5.0	141	526	1,800
Cd	0.05	0.36	0.2	5.2
Co	0.88	6.6	7.1	143
Cr(III)	4.9	115	27	5,320
Cu	6.2	137	12.7	81.9
Mn	54.5	707	490	3,120
Mo	0.5	22.9	0.82	21.0
Ni	3.46	117	13.8	2,314
Pb	3.7	22.9	19.2	245
Se	0.20	0.44	0.3	2.3
Zn	5.0	245	56	377

Land Application Considerations



- Blending of sand into soil can allow for increased hydraulic conductivity
- However, massive amounts of sand would be required
- 2,000 Tonnes of foundry sand required per hectare to increase the sand content by 10%
- Compaction!!!

Soil Amendment Resource



Assist regulators, consultants, site owners, and other stakeholders in understanding the principles of soil amendment application for remediating and revegetating contaminated sites and to encourage widespread use of this alternative to revitalize and reuse contaminated land

http://www.clu-in.org/download/remed/epa-542-r-07-013.pdf

Kurtz Bros., Inc.

"We make the good earth better!"

http://www.kurtz-bros.com

- Six locations in Ohio, USA
- Obtains sand from 20 foundries
- About 80,000 tons of sand per year for manufactured soils
- 160,000 tons per year for geotechnical applications
- Beneficially used 5,400,000 tonnes of sand to date

Soil Blending Operation


Foundry sand


Low-grade soil


Processing of wood pallets


Wood mulch, dyed

Manufactured Soil and Soilless Media

Components

Low-grade soil

+

Foundry sand

+

Wood mulch

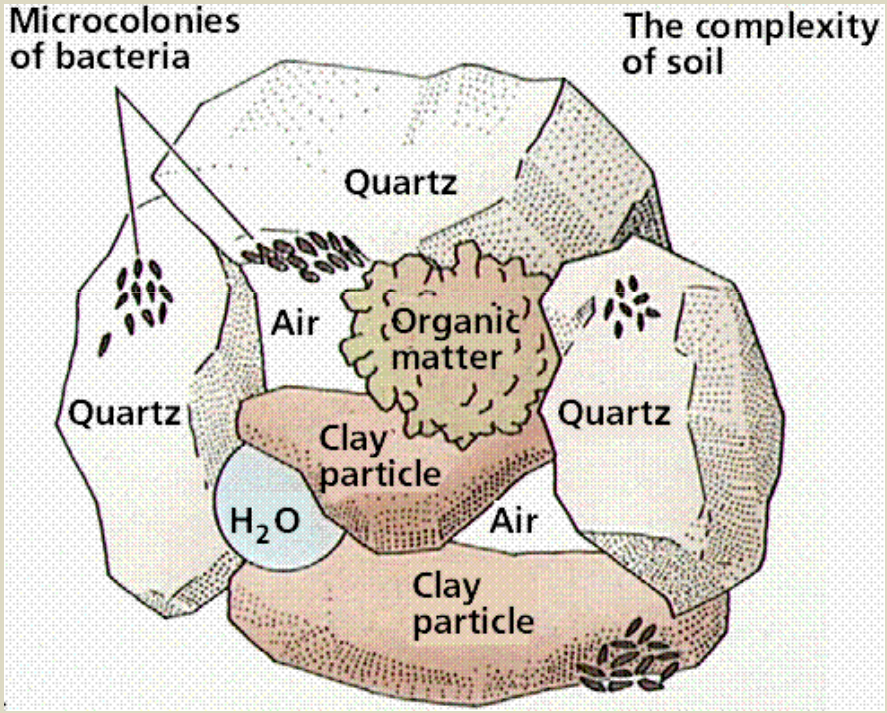
+

Biosolids compost

Manufactured Soil
5 to 60% WFS

Using Foundry Sands in Manufactured Soils

Soil Aggregate

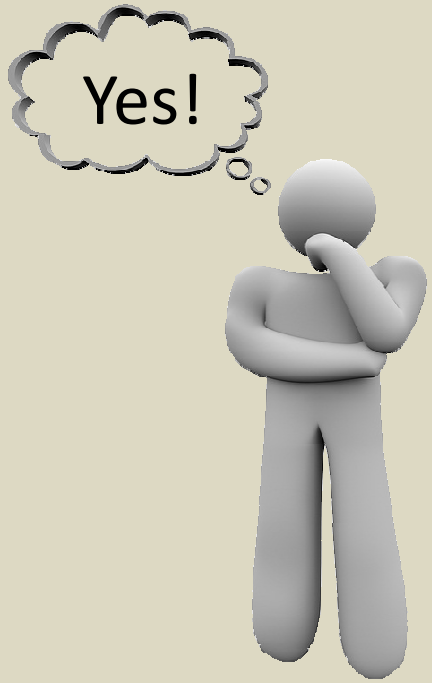


Foundry Sand (green)

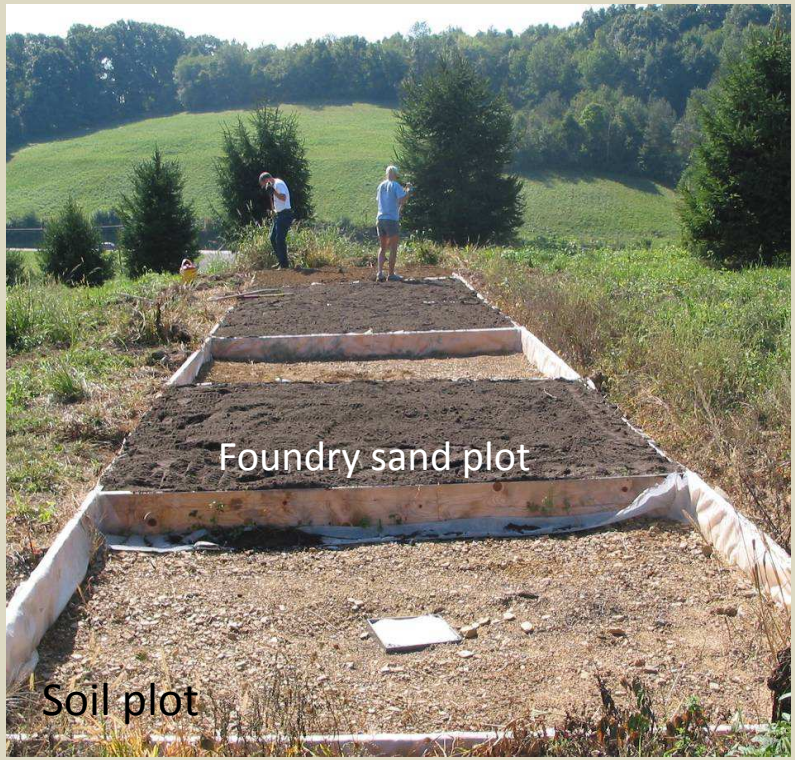
- Sand
- Clay
- Organic carbon
- Water

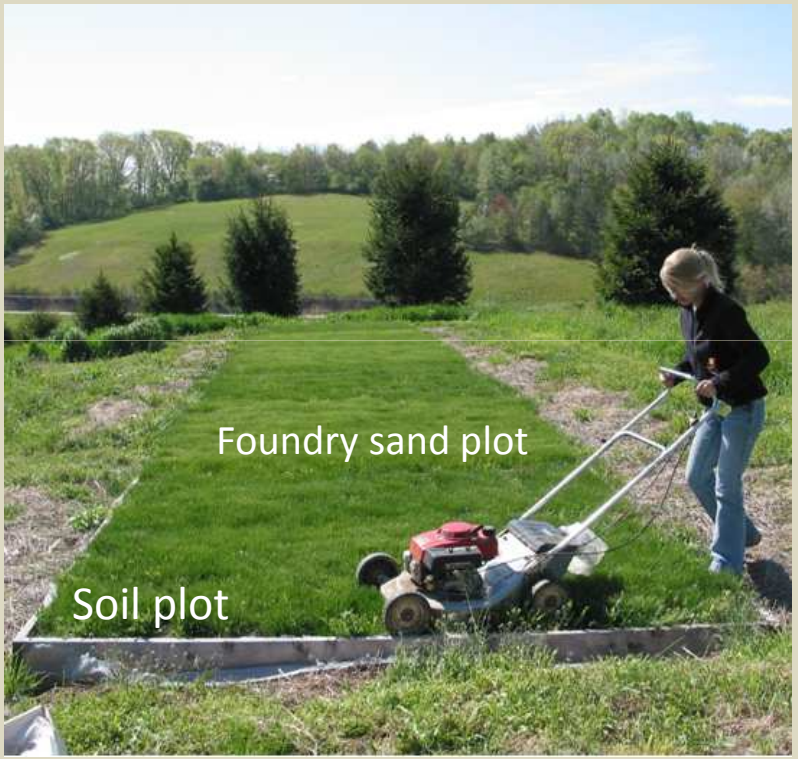
Manufactured Soils and Plants

Can manufactured soils containing WFS be used to successfully grow plants?



Turfgrass Study: Penn State University





Lettuce Bioassay

Control: 0% WFS,
5% silica sand

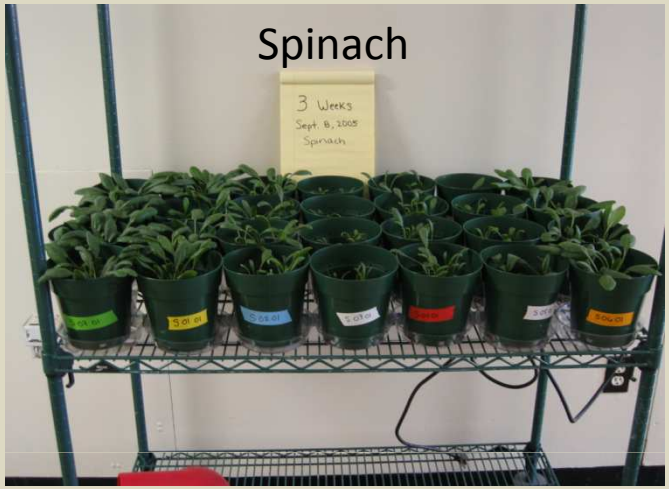
Soil blend: 5% WFS

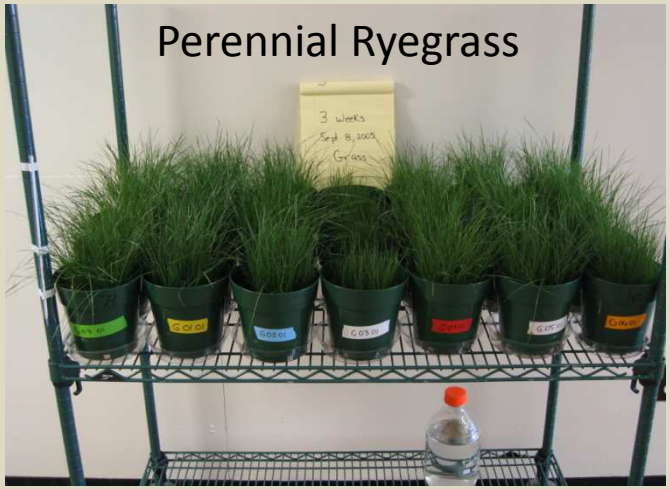
Soil blend: 10% WFS

No difference in RDMG; no visual deficiencies or toxicities

Safe to Eat!!!

Additional Plant Bioassays (50% WFS)





Horticultural Applications

Blended with foundry sand, biosolids compost, rice hulls, pine bark and natural soil, Kurtz Bros. container mix has become the preferred soil blend for Ohio nurseries

Landscaping Applications

Barrington Country Club

Foundry sand is an essential ingredient in Kurtz Bros. Bed Mix to create a well-drained sandy loam growing medium for more successful landscape projects.

Medina Country Club

Commercial Applications

Euclid Corridor, Cleveland, OH
5,300 cubic meters of planting mix

Cleveland Clinic, Cleveland , OH
15,300 cubic meters of topsoil

Cleveland Art Museum, Cleveland, OH
9,200 cubic meters of topsoil

Foundry sand in the mix creates the economic advantage needed to provide quality soil to large projects

Green Building Applications

Rooftop gardens are proven to save heating and cooling energy and costs, remediate storm water, and create better environments for building occupants

Sandy loam soil with foundry sand in the mix helps create an ideal, light weight blend, when combined with Haydite expanded shale aggregate

Road Base Applications


Ohio Turnpike

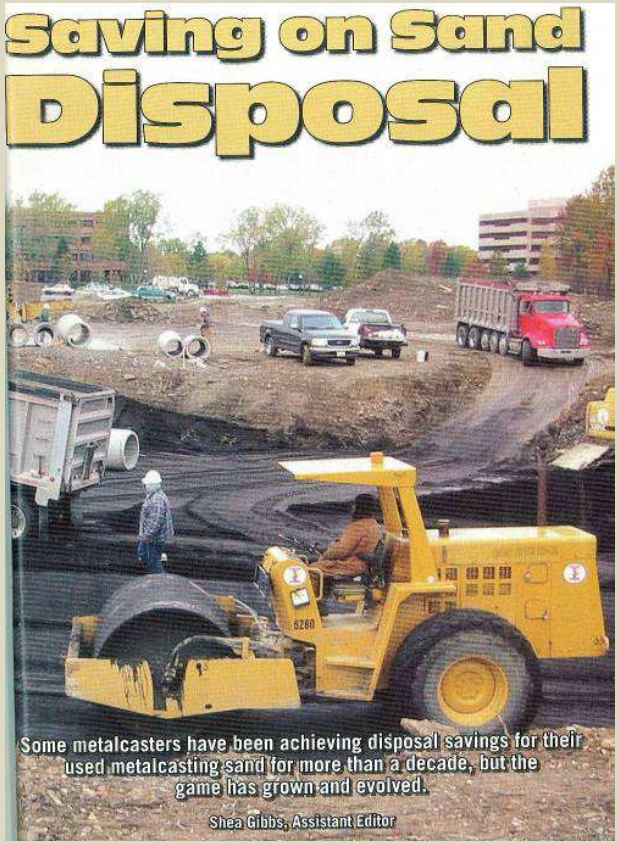

Parking structure

Road Embankment Project

The system uses a series of pre-cast modular wall pieces in conjunction with galvanized steel reinforcing strips which are layered into the backfill

Why Use Foundry Sand as Road Base and in Embankments?

- Extremely uniform material
- Excellent compaction properties
- Easy to handle
- Low cost, relatively abundant
- Not “as” moisture sensitive
- Not “as” susceptible to freeze thaw



Slide Repair Along Highway

- 9,000 Tonnes of waste foundry sand
- Layered composite
- Excellent compaction and drainage

Stepped Road Embankment, Ohio Turnpike

Creation of an embankment that blends with nature

Cleveland Hopkins Airport, Creek Diversion

15,000 cubic meters of flowable fill used as pipe bedding around four 3 m diameter pipes

Notable Foundry Sand Projects, Ohio, USA

Project/Location	Tonnes
MSE Wall Projects	
Ohio Turnpike Third Lane Project 779901	49,000
Schaaf Road Bridge Replacement	25,000
I-271 & Route 303 IR Bridge Replacement	19,000
Fulton Road Bridge Replacement	11,000
I- 71 & Route 83	7,000
ODOT Projects	
I-271 Slide	9,000
I-271 Express Lanes	5,000
Route 82 & Route 8 ODOT Subbase – Macedonia	500
SR 237 Front St. Railroad Grade Separation – Berea	78,000
Public Projects - Embankments	
Ohio Turnpike Third Lane Project 439901	53,000
Ohio Turnpike Great Lakes Service Plazas	45,000
Patriot's Way	22,700
Public Projects – Flowable Fill	
Abrams Creek Diversion (Cleveland Airport)	18,000
Private Projects – Embankments	
Cloverleaf	544,000
West Creek	454,000
Rockside Road	454,000
Footes/Cinemark Theatre	227,000
Vale	145,000
Majewski	87,000
PLPI Heinton Road	44,000
CDF Area I – Final Grade	23,000
Embassy Suites	18,000
City of Aurora Sewer	18,000
Towpath I/Towpath II	14,000
Richfield Retail Development	9,000
Delta – York Drive	9,000
Leachate Collection Systems	
Rosby Hill	11,000
Waste Management Leachate Collection	9,000

Paver Stones, Joinville, Brazil

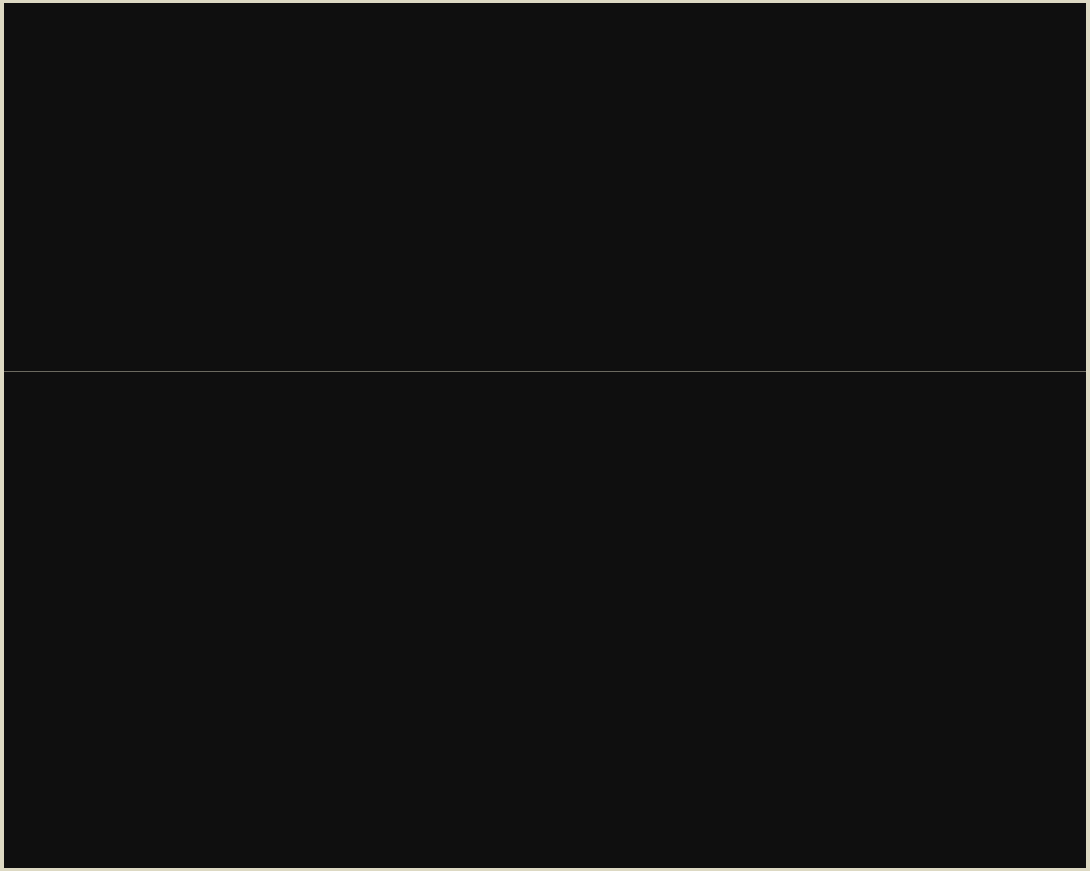
- State law allows for use of foundry sands in non-structural concrete and asphalt
- Paver formulation is 47% foundry sand, 28% stone powder, 19% cement, and 6% water

Paver Stone Facility

Paver Stones, Brazil

Interlocking paver stones are widely used in urban applications due to their versatility and ease of installation

Paver Stones at Tupy



Experimenting with Asphalt, Brazil

- 10% Foundry sand in hot mix asphalt concrete
- Performed very well
- Transportation department now considering using WFS

Resource Recovery Corporation, MI, USA

- Sand obtained from 30 foundries
- Sand for daily cover, leachate collection media, and asphalt
- Slag for hot mix asphalt and concrete
- Processed 500,000 tons of foundry byproducts since 1991

http://www.rrcrecycles.com/home.html

Sand Processing at RRC

- Manual screening
- Rotary kiln (425^{o}C)
- Metal fines removal

Liner and Leachate Collection Medium


Western MI, USA

- Sand protects synthetic liner from being punctured (45 cm layer)
- Replacement for virgin sands
- Leachate is sent and treated at a local sewage treatment plant
- 23,000 Tonnes of sand used per cell

Slag

- Vitreous material (silicon dioxide and metal oxides)
- Most are ferrous slags
- World iron slag output around 180 to 230 million tonnes annually
- Steel slag 100 to 145 million tonnes
- Very valuable byproduct!!!
- U.S. slag valued at $300 million

Beneficial Uses of Slag

Blast Furnace Slag			Steel Slag
Air-Cooled	Pelletized	Granulated	
Asphalt aggregate	Concrete masonry	GGBS cement	Asphalt aggregate
Concrete/Masonry aggregate	Lightweight concrete	Soil cement	Fill
Insulation/ mineral wool	Lightweight fill	Roller compacted concrete	Cement Mfg. raw feed
Cement Mfg. raw feed	Insulation		Agriculture/Soil Amendment
Agriculture/Soil Amendment	Road Base	Road Base	Environmental Applications
Fill	✖	Agriculture/Soil Amendment	Railroad ballast
Roof aggregate	✖	✖	Road Base
Railroad ballast	✖	✖	Gabions/Rip Rap
Glass manufacture	✖	✖	✖
Environmental Applications	✖	✖	✖
Gabions/Rip Rap	✖	✖	✖
Lightweight fill	✖	✖	✖

Slag Fertilizer

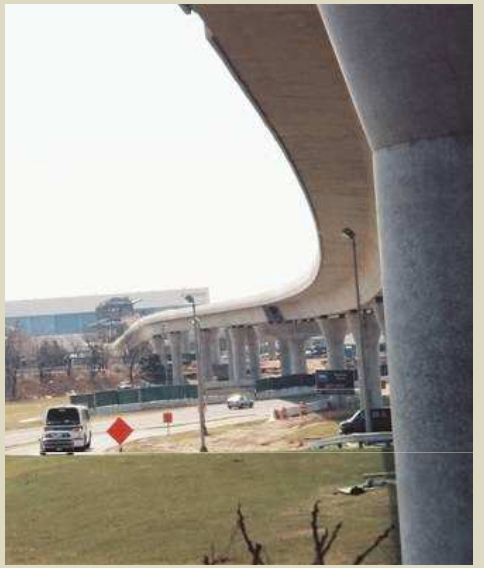
- Blast furnace and steel converter slag (BOFS)
- Blast furnace slag contains CaO, MgO, and SiO_2
- Solubility of Ca, Mg, and Si is higher than other conditioners
- Steelmaking slag also contains FeO and Fe_2O_3 (24%), MnO (5%), and P_2O_5 (5%)
- BOFS as Fe fertilizer and liming agent due to low P

Slag Cement for Agricultural Applications

- Floor panels for liquid manure pits
- 25% slag cement
- Must withstand low pH of manure
- Strong enough to support weight of livestock and machinery

Slag Cement Concrete, AirTran JFK

- 153,000 cubic meters of concrete
- 482 Cast-in-place columns with 20 to 30% slag
- 5,000 precast tensioned boxes with 40% slag



Georgia Aquarium, Atlanta

- 54,000 cubic meters of slag cement
- Proportions ranging from 20 to 75% slag
- Concrete with strength up to 55MPa

Slag Heaps, Nord-Pas-de-Calais, France

Move over Taj Mahal, slag heaps are now a UNESCO World Heritage Site

Some heaps 90 hectares and 140 m tall

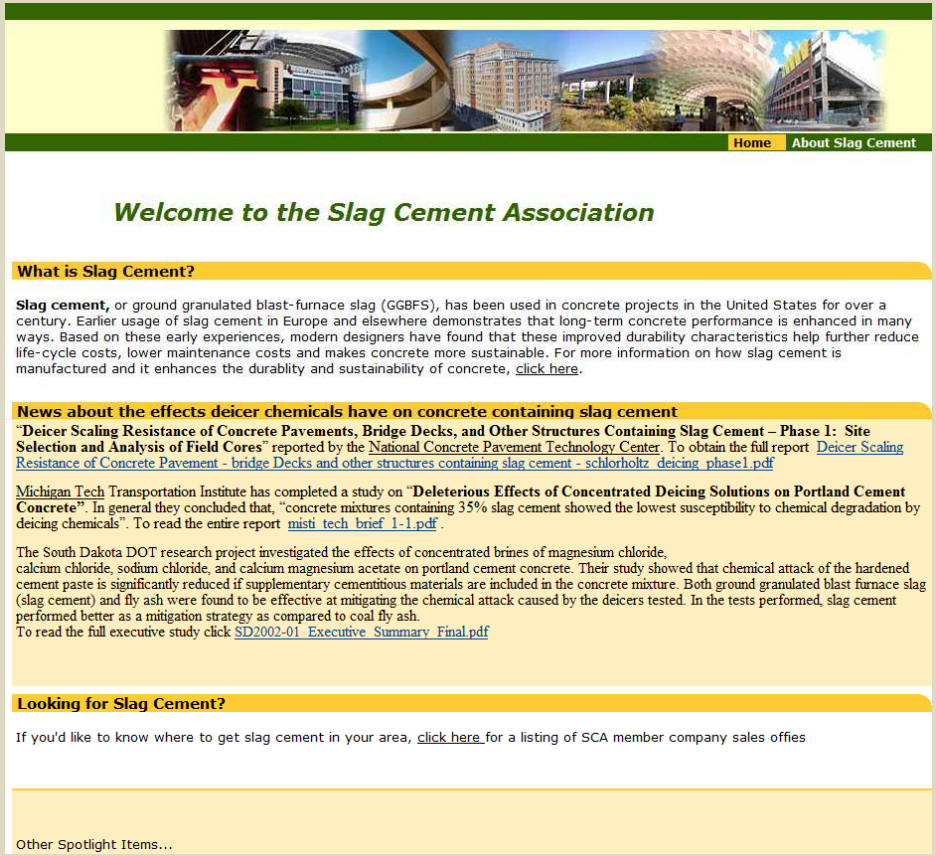
Dry Skiing on Slag Heaps

France

"Becton Alps" England

PA, USA

Additional Information on Slag Use



http://www.nationalslag.org/index.htm

http://www.slagcement.org/index.html

Baghouse Dust

- Dust from melting, pouring, cooling, shakeout, and grinding and finishing
- High silica and metal content (Cd, Cu, Cr, Pb, Zn)
- Recovery of ZnO from EAFD
- May be suitable as a silica substitute in the manufacture of Portland cement
- Filler in extruded plastic parts (e.g. furniture casters)

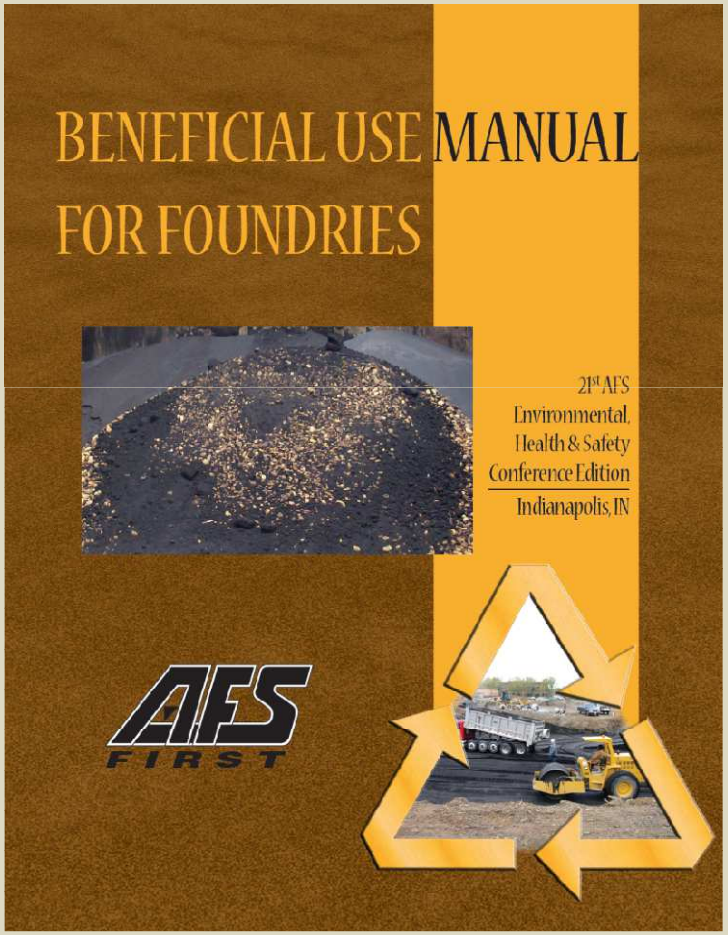
Furnace and Ladle Refractory Materials

- Alumina, carbon, silica, fireclay, magnesia, dolomite, calcium oxide
- Most are currently managed as solid wastes
- Generally not beneficially used due to variable particle size
- Grinding necessary
- Some contain high metal levels, but generally inert
- Alumina and silica in Portland cement

Where Do You Go From Here?

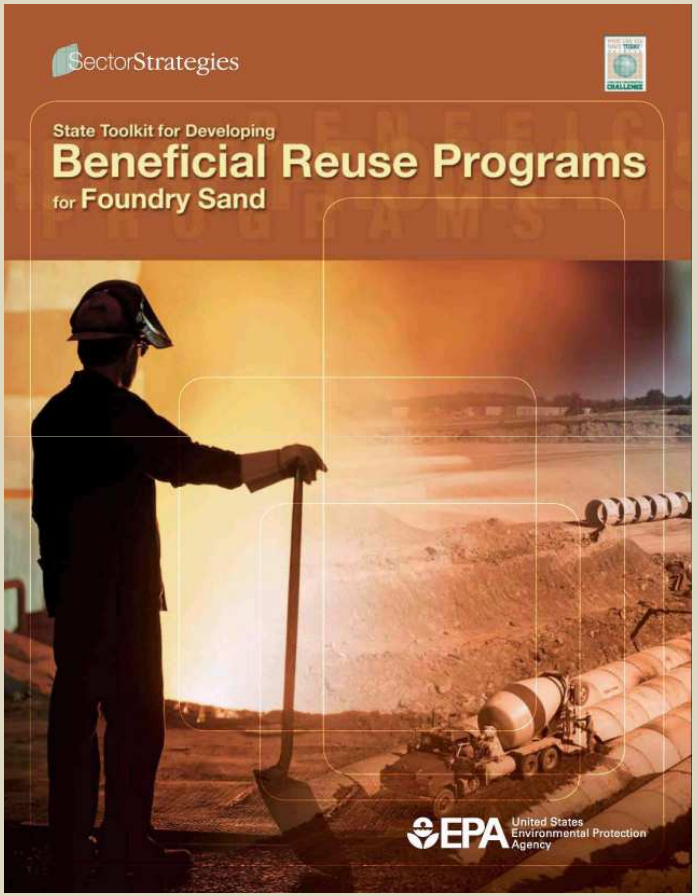
- Marketing of foundry wastes to end users
- Establish a Steering Committee (liaison, scientists, regulatory agencies, foundry representatives)
- Foundrymen don’t have the time
- Educate stakeholders about the metalcasting process; let them see and feel foundry wastes
- Evaluate existing regulations and focus efforts
- Hold seminars, workshops, and demonstration projects
- Education and persistence are the keys to success

American Foundry Society & FIRST



Manual to assist foundries in the beneficial use of metalcasting sands and other byproducts

U.S. Environmental Protection Agency



Document was developed to assist states in improving or developing beneficial use programs

http://www.epa.gov/sectors/sectorinfo/sectorprofiles/metalcasting/foundry.html

Waste?

Think of foundry waste as a valuable byproduct.
Waste is not a waste if beneficially used.

Peder Severin Krøyer, 1885