

# Solutions for Waste in the Foundry Sector

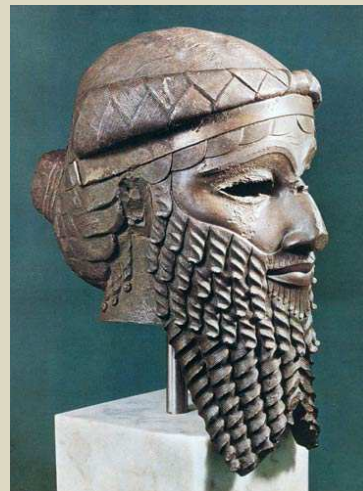
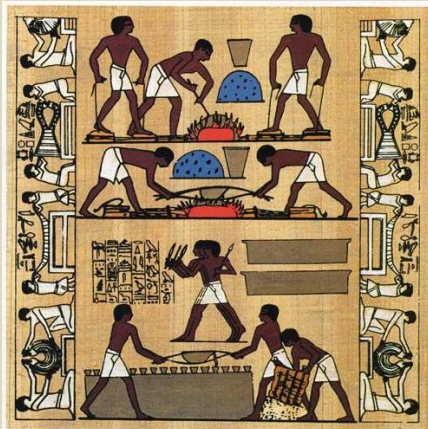
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# History of Metal Casting

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# Worldwide Importance of Foundries

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# Many Hurdles

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



# What Can Foundries Do?

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



# Foundry = Recycling ≈ Green Industry

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Brass

Iron



Aluminum



Copper



Steel

Other Alloys

# Metalcasting Waste Products

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Molding sand

Core sand

Slag

Baghouse dust

Furnace refractory

Broken cores

Shotblast fines

Graphite electrodes



# Fate of Most Foundry Wastes

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Tandil, Argentina



# Definition of Beneficial Use

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“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?

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



# Waste Foundry Sands

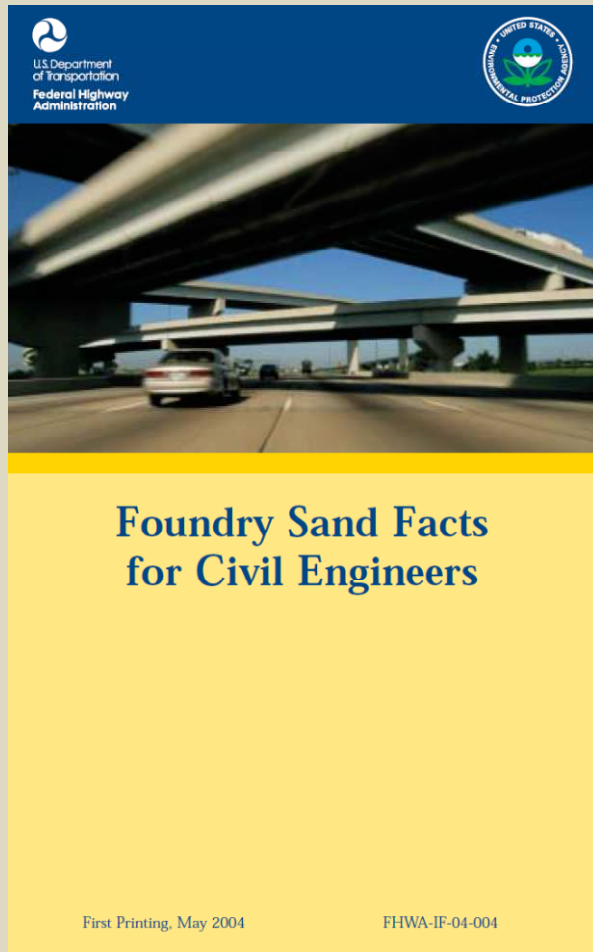
## Largest waste from the Foundry Industry

- 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

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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

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- 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

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



# What are the Risks from Foundry Sands?

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- “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

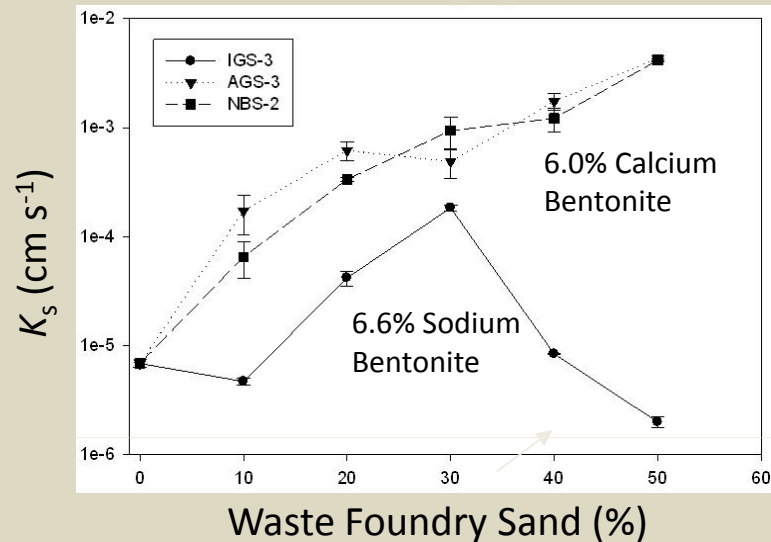


# Metals in Foundry Sands (mg kg<sup>-1</sup>)

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

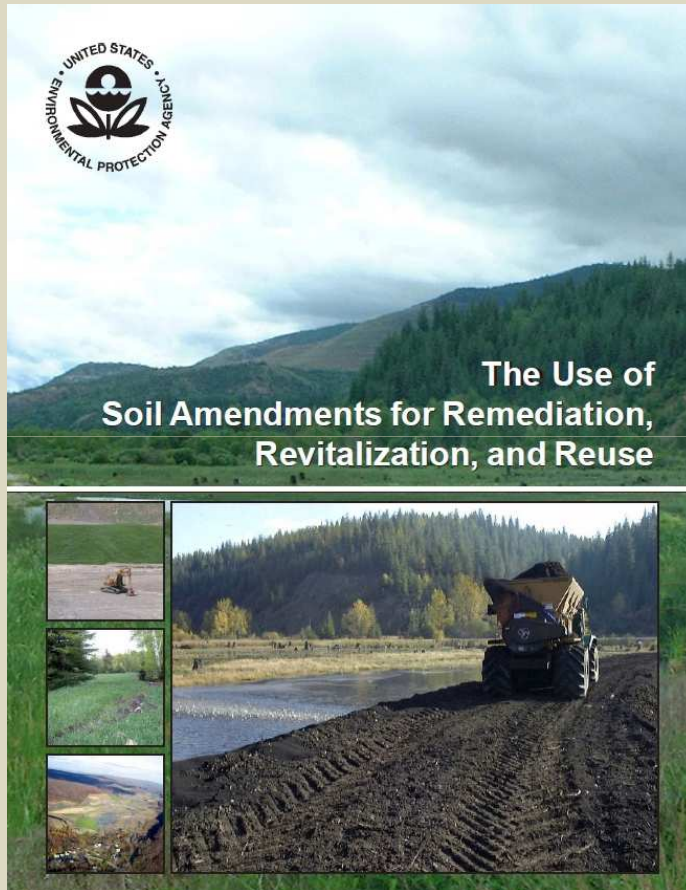


# Land Application Considerations



- 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>



<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



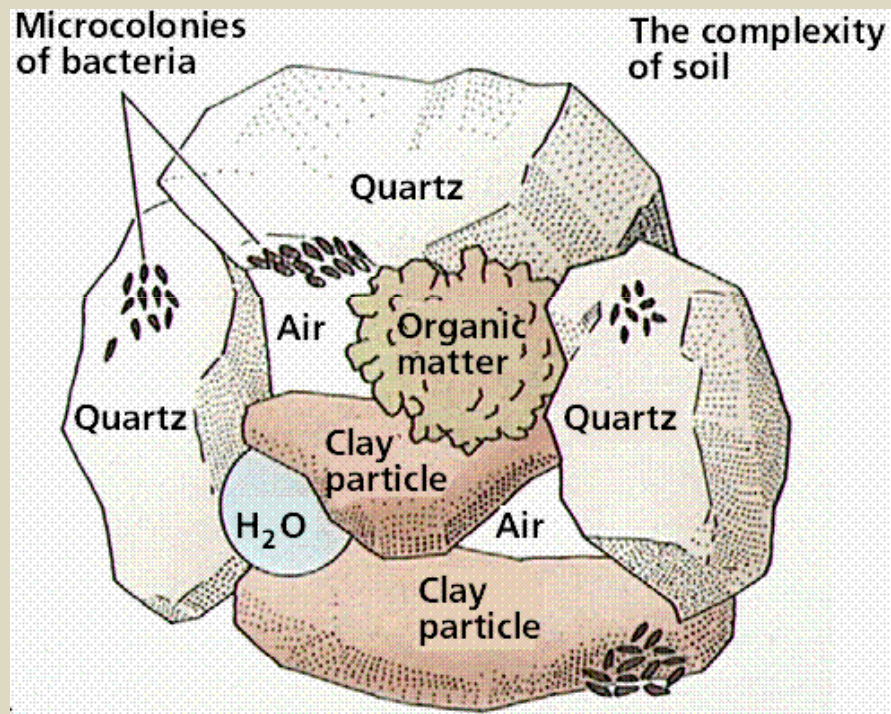
# Manufactured Soil and Soilless Media

## Components



# Using Foundry Sands in Manufactured Soils

## Soil Aggregate



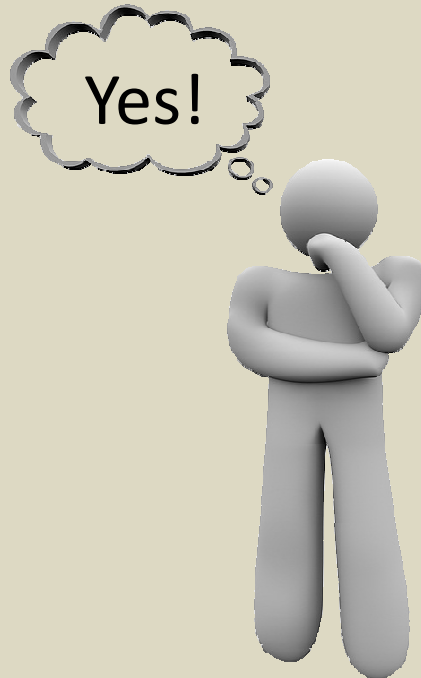
### Foundry Sand (green)

- Sand
- Clay
- Organic carbon
- Water

# Manufactured Soils and Plants

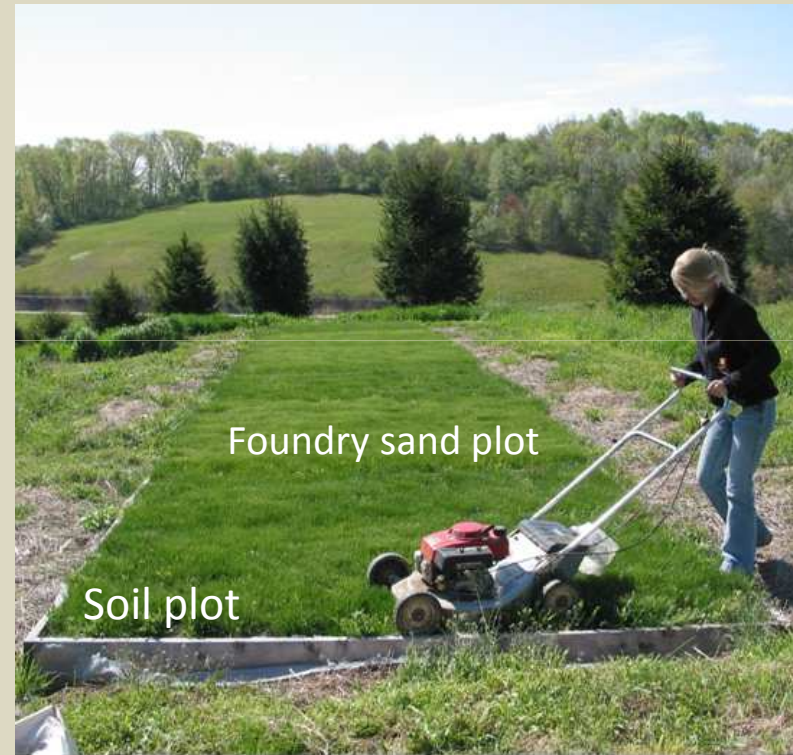
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Can manufactured soils containing WFS be used to successfully grow plants?



# Turfgrass Study: Penn State University

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# Lettuce Bioassay

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Control: 0% WFS,  
5% silica sand



Soil blend: 5% WFS



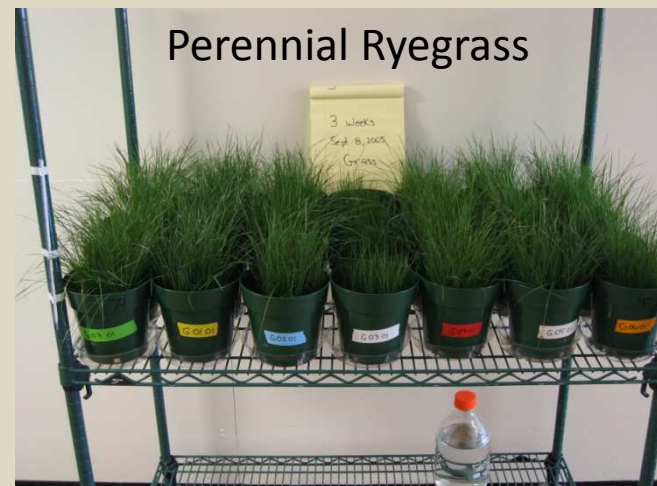
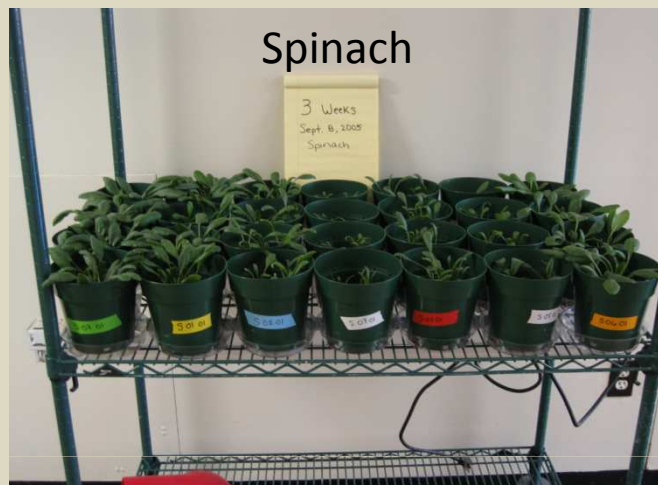
Soil blend: 10% WFS

No difference in RDMG; no visual deficiencies or toxicities

**Safe to Eat!!!**

# Additional Plant Bioassays (50% WFS)

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# Horticultural Applications

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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

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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

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



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

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



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

# Green Building Applications

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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

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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

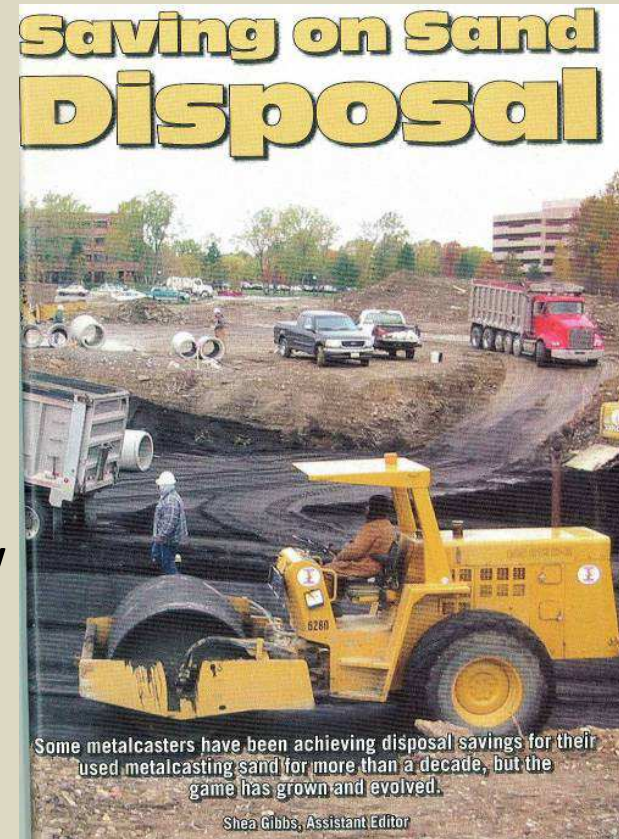




# Why Use Foundry Sand as Road Base and in Embankments?

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- 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

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

# Stepped Road Embankment, Ohio Turnpike

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Creation of an embankment that blends with nature

# Cleveland Hopkins Airport, Creek Diversion

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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
<b>MSE Wall Projects</b>	
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
<b>ODOT Projects</b>	
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
<b>Public Projects - Embankments</b>	
Ohio Turnpike Third Lane Project 439901	53,000
Ohio Turnpike Great Lakes Service Plazas	45,000
Patriot's Way	22,700
<b>Public Projects – Flowable Fill</b>	
Abrams Creek Diversion (Cleveland Airport)	18,000
<b>Private Projects – Embankments</b>	
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
<b>Leachate Collection Systems</b>	
Rosby Hill	11,000
Waste Management Leachate Collection	9,000



# Paver Stones, Joinville, Brazil

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- 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

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# Paver Stones, Brazil



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





# Paver Stones at Tupy

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# 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

Home  
Foundry Sand Recycling  
Trucking Service  
News and Events  
Contact Us

Over 500,000 tons of Foundry residuals recycled

## Resource Recovery Corporation of West Michigan



Established 1991  
**RRC**  
RESOURCE RECOVERY CORPORATION  
15720 58<sup>th</sup> Avenue

### What in the world is Resource Recovery?



SAND ONLY  
First Step in Recycling Segregation



Trucking

Resource Recovery Corporation was created by 15 West Michigan Foundries over 20 years ago. During a Western Michigan AFS meeting the subject of foundry sand and slag disposal cost was discussed. After the AFS meeting some of the local foundry men got together and created RRC to find ways of reusing spent molding sand and slag. Our mandate was simple, find ways of reducing disposal cost, operate at near zero profit and save natural resources at the same time. In 1991 RRC began operations in the Muskegon area by using foundry sand as daily cover at a local landfill. In 1996 RRC began processing spent mold and core sand for asphalt and leachate collection media. Also in 1996 RRC began processing slag for asphalt and concrete use. In 2005 RRC achieved inert status for its processed foundry sand. Since 1991 RRC has recycled more than half a million tons of foundry process residuals, cut the cost of foundry residuals management by 2/3 and operates at a near zero profit.

We exist only to serve West Michigan foundries.

- 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

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- Manual screening
- Rotary kiln (425°C)
- Metal fines removal



# Liner and Leachate Collection Medium

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- 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

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- 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

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- Blast furnace and steel converter slag (BOFS)
- Blast furnace slag contains  $\text{CaO}$ ,  $\text{MgO}$ , and  $\text{SiO}_2$
- Solubility of Ca, Mg, and Si is higher than other conditioners
- Steelmaking slag also contains  $\text{FeO}$  and  $\text{Fe}_2\text{O}_3$  (24%),  $\text{MnO}$  (5%), and  $\text{P}_2\text{O}_5$  (5%)
- BOFS as Fe fertilizer and liming agent due to low P



# Slag Cement for Agricultural Applications

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- 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

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- 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

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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



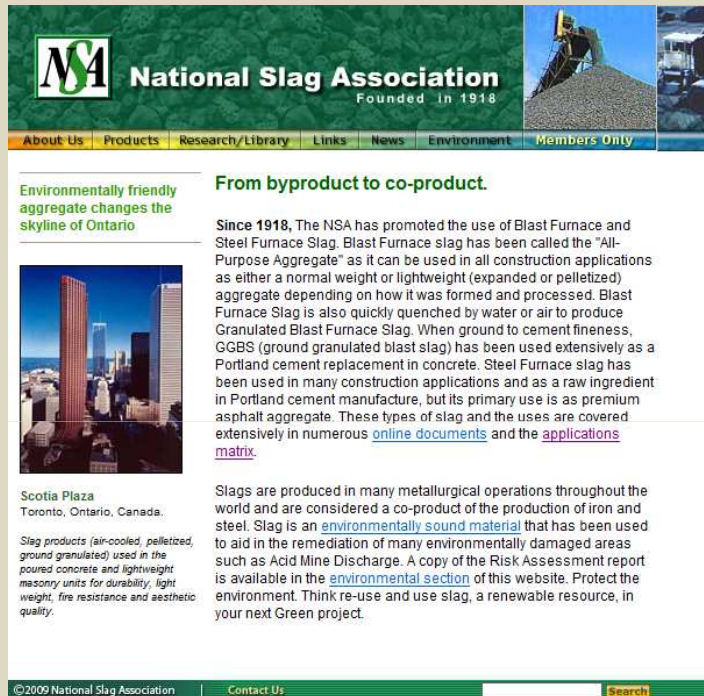
“Becton Alps” England



PA, USA



# Additional Information on Slag Use



The screenshot shows the National Slag Association website. The header features the NSA logo and the text "National Slag Association Founded in 1918". A navigation menu includes "About Us", "Products", "Research/Library", "Links", "News", "Environment", and "Members Only". The main content area has a green background with the heading "From byproduct to co-product." and a sub-heading "Environmentally friendly aggregate changes the skyline of Ontario". Below this is a photograph of the Scotia Plaza in Toronto. The text describes the history and uses of Blast Furnace and Steel Furnace Slag, noting their use in concrete and as a raw ingredient in asphalt. A sidebar on the right contains a search bar and a "Contact Us" link.

**National Slag Association**  
Founded in 1918

Environmentally friendly aggregate changes the skyline of Ontario

Since 1918, The NSA has promoted the use of Blast Furnace and Steel Furnace Slag. Blast Furnace slag has been called the "All-Purpose Aggregate" as it can be used in all construction applications as either a normal weight or lightweight (expanded or pelletized) aggregate depending on how it was formed and processed. Blast Furnace Slag is also quickly quenched by water or air to produce Granulated Blast Furnace Slag. When ground to cement fineness, GGBS (ground granulated blast slag) has been used extensively as a Portland cement replacement in concrete. Steel Furnace slag has been used in many construction applications and as a raw ingredient in Portland cement manufacture, but its primary use is as premium asphalt aggregate. These types of slag and the uses are covered extensively in numerous [online documents](#) and the [applications matrix](#).

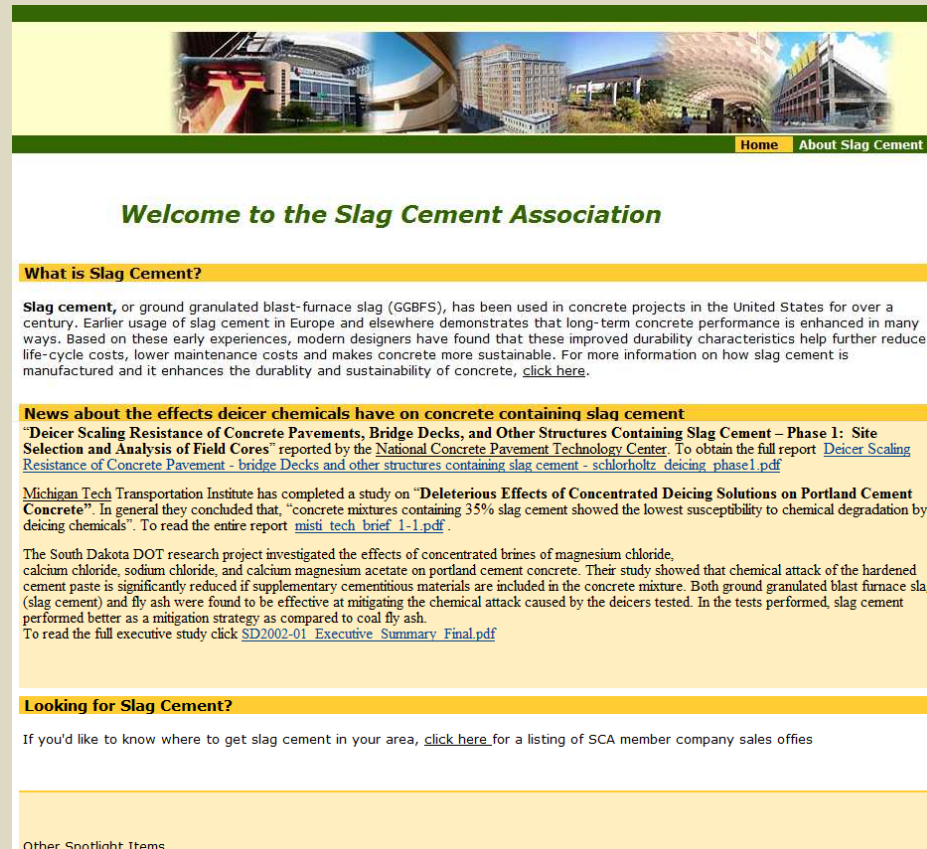
Slags are produced in many metallurgical operations throughout the world and are considered a co-product of the production of iron and steel. Slag is an [environmentally sound material](#) that has been used to aid in the remediation of many environmentally damaged areas such as Acid Mine Discharge. A copy of the Risk Assessment report is available in the [environmental section](#) of this website. Protect the environment. Think re-use and use slag, a renewable resource, in your next Green project.

Scotia Plaza  
Toronto, Ontario, Canada.

Slag products (air-cooled, pelletized, ground granulated) used in the poured concrete and lightweight masonry units for durability, light weight, fire resistance and aesthetic quality.

©2009 National Slag Association | [Contact Us](#)  [Search](#)

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



The screenshot shows the Slag Cement Association website. The header features a collage of images of buildings and infrastructure. The main content area has a green background with the heading "Welcome to the Slag Cement Association". Below this is a yellow box with the heading "What is Slag Cement?" and text describing slag cement and its use in concrete. Another yellow box contains the heading "News about the effects deicer chemicals have on concrete containing slag cement" and links to reports from the National Concrete Pavement Technology Center and Michigan Tech Transportation Institute. A third yellow box contains the heading "Looking for Slag Cement?" and text about finding sales offices. The footer contains the text "Other Spotlight Items..."

Welcome to the Slag Cement Association

**What is Slag Cement?**

Slag cement, or ground granulated blast-furnace slag (GGBFS), has been used in concrete projects in the United States for over a century. Earlier usage of slag cement in Europe and elsewhere demonstrates that long-term concrete performance is enhanced in many ways. Based on these early experiences, modern designers have found that these improved durability characteristics help further reduce life-cycle costs, lower maintenance costs and makes concrete more sustainable. For more information on how slag cement is manufactured and it enhances the durability and sustainability of concrete, [click here](#).

**News about the effects deicer chemicals have on concrete containing slag cement**

**"Deicer Scaling Resistance of Concrete Pavements, Bridge Decks, and Other Structures Containing Slag Cement – Phase 1: Site Selection and Analysis of Field Cores"** reported by the National Concrete Pavement Technology Center. To obtain the full report [Deicer Scaling Resistance of Concrete Pavement - bridge Decks and other structures containing slag cement - schlorholtz deicing phase1.pdf](#)

Michigan Tech Transportation Institute has completed a study on **"Deleterious Effects of Concentrated Deicing Solutions on Portland Cement Concrete"**. In general they concluded that, "concrete mixtures containing 35% slag cement showed the lowest susceptibility to chemical degradation by deicing chemicals". To read the entire report [misti tech brief 1-1.pdf](#).

The South Dakota DOT research project investigated the effects of concentrated brines of magnesium chloride, calcium chloride, sodium chloride, and calcium magnesium acetate on portland cement concrete. Their study showed that chemical attack of the hardened cement paste is significantly reduced if supplementary cementitious materials are included in the concrete mixture. Both ground granulated blast furnace slag (slag cement) and fly ash were found to be effective at mitigating the chemical attack caused by the deicers tested. In the tests performed, slag cement performed better as a mitigation strategy as compared to coal fly ash. To read the full executive study click [SD2002-01 Executive Summary Final.pdf](#)

**Looking for Slag Cement?**

If you'd like to know where to get slag cement in your area, [click here](#) for a listing of SCA member company sales offices

Other Spotlight Items...

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

# Baghouse Dust

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- 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

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- 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





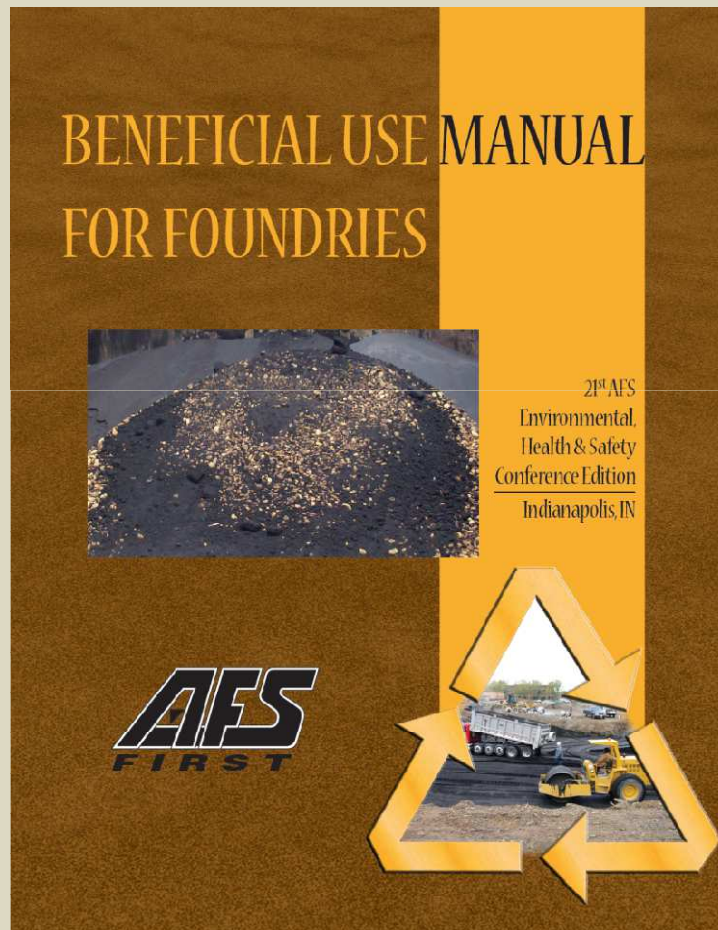
# Where Do You Go From Here?

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- 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

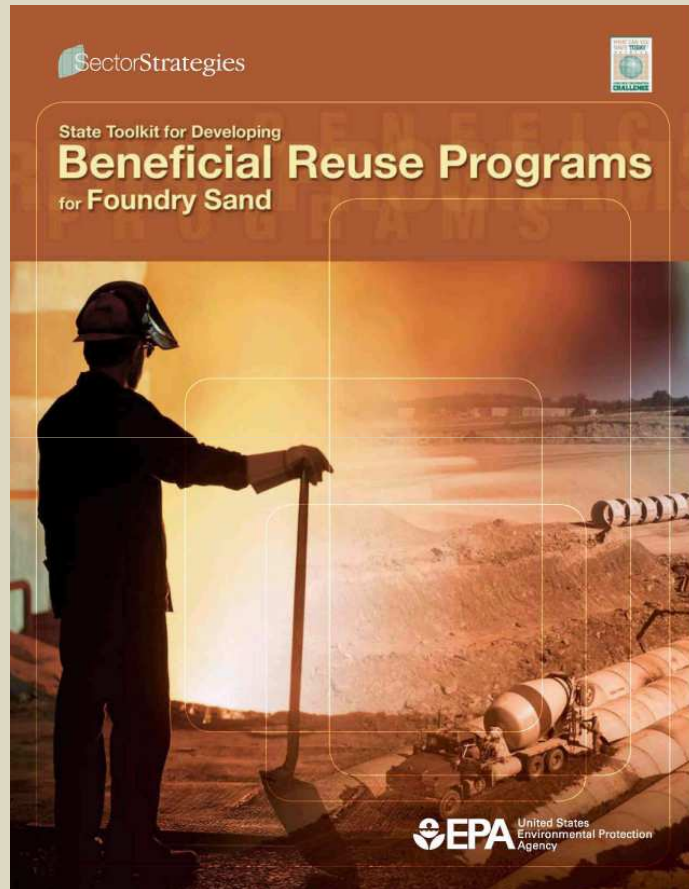
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Manual to assist foundries in the beneficial use of metalcasting sands and other byproducts

# U.S. Environmental Protection Agency

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

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

# Waste?

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

Thank you



Peder Severin Krøyer, 1885