

# SLAG

## An Overview of Steel Slag for Mine Drainage Remediation

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# WHAT IS SLAG?

Slag (ferrous) is a product of the iron and steel making processes. Slag is the end product of the use of limestone as a flux for the melting of iron and steel. Molten lime chemically reacts with the silicates and aluminates from the combustion of coke and ore byproducts to form a non-metallic material known as slag.

# TYPES OF SLAG?

- **Blast Furnace Slag** – From Iron Making

  - Air-cooled Slag** – Cooled slowly (without water). Historically most significant.

  - Pelletized or Expanded Slag** – Cooled more quickly with water (non-controlled). Produces a lightweight aggregate.

  - Granulated Slag** – Rapid Cooling with water under controlled conditions then ground Fine (granulated) for use in cement.

- **Steel Furnace Slag** - Produced in a (BOF) Basic Oxygen Furnace or an (EAF) Electric Arc Furnace.

# SLAG USEAGE

2000 Production = 17.5 Million Metric Tons

## Air-Cooled

## Expanded

## Granulated 3.3 MM Ton

## Steel Slag

Asphalt aggregate

Concrete masonry

GGBS cement

Mine Buffer

Concrete aggregate

Lightweight  
concrete

Soil cement

AMD Water Treatment

AMD Water Treatment

Lightweight fill

Roller compacted  
concrete

Cement raw feed

Cement raw feed

Insulation

Agriculture

Agriculture

Environmental

Fill

Railroad ballast

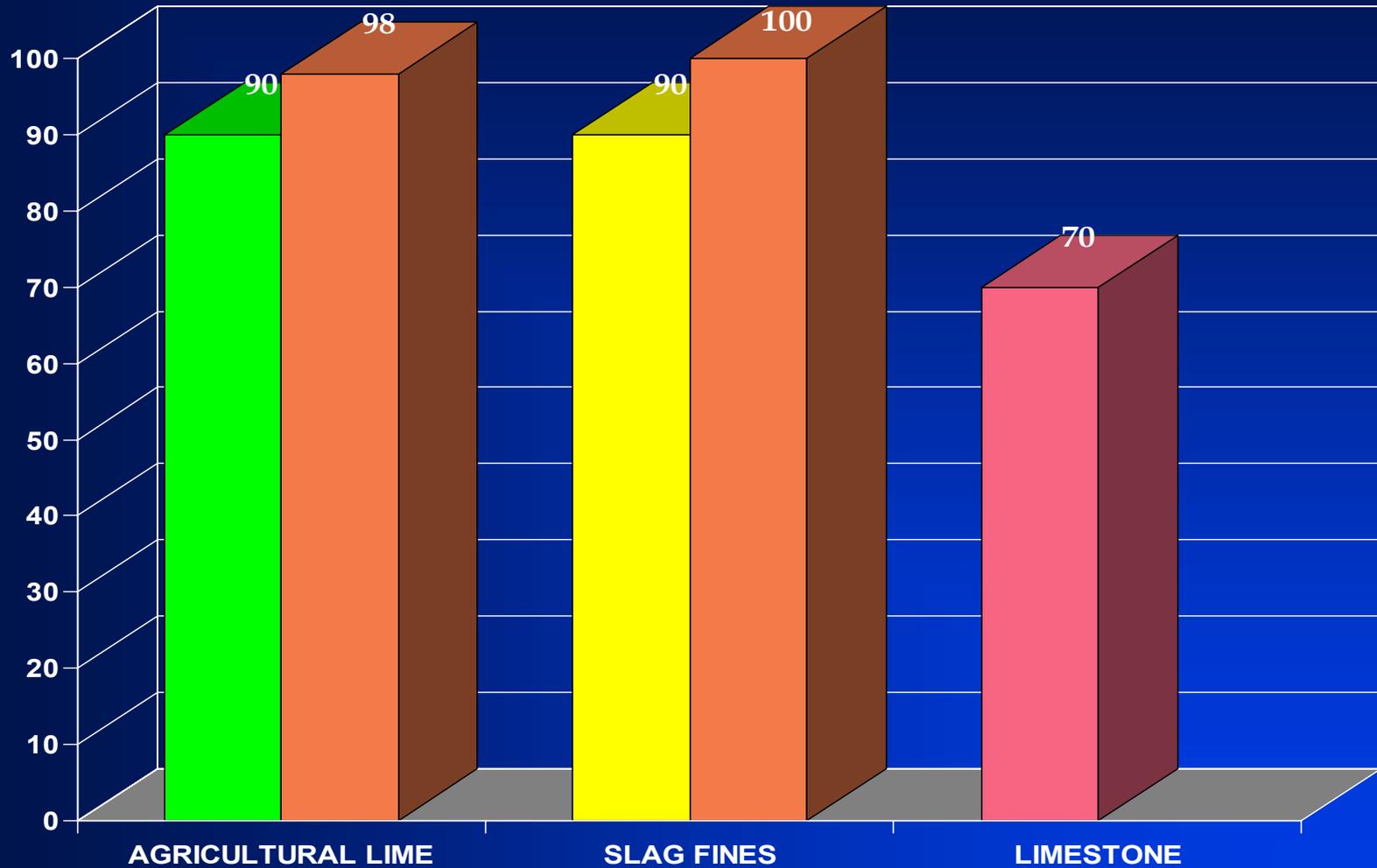
Roof aggregate

Fill

Railroad ballast

Asphalt aggregate

# CCE COMPARISON



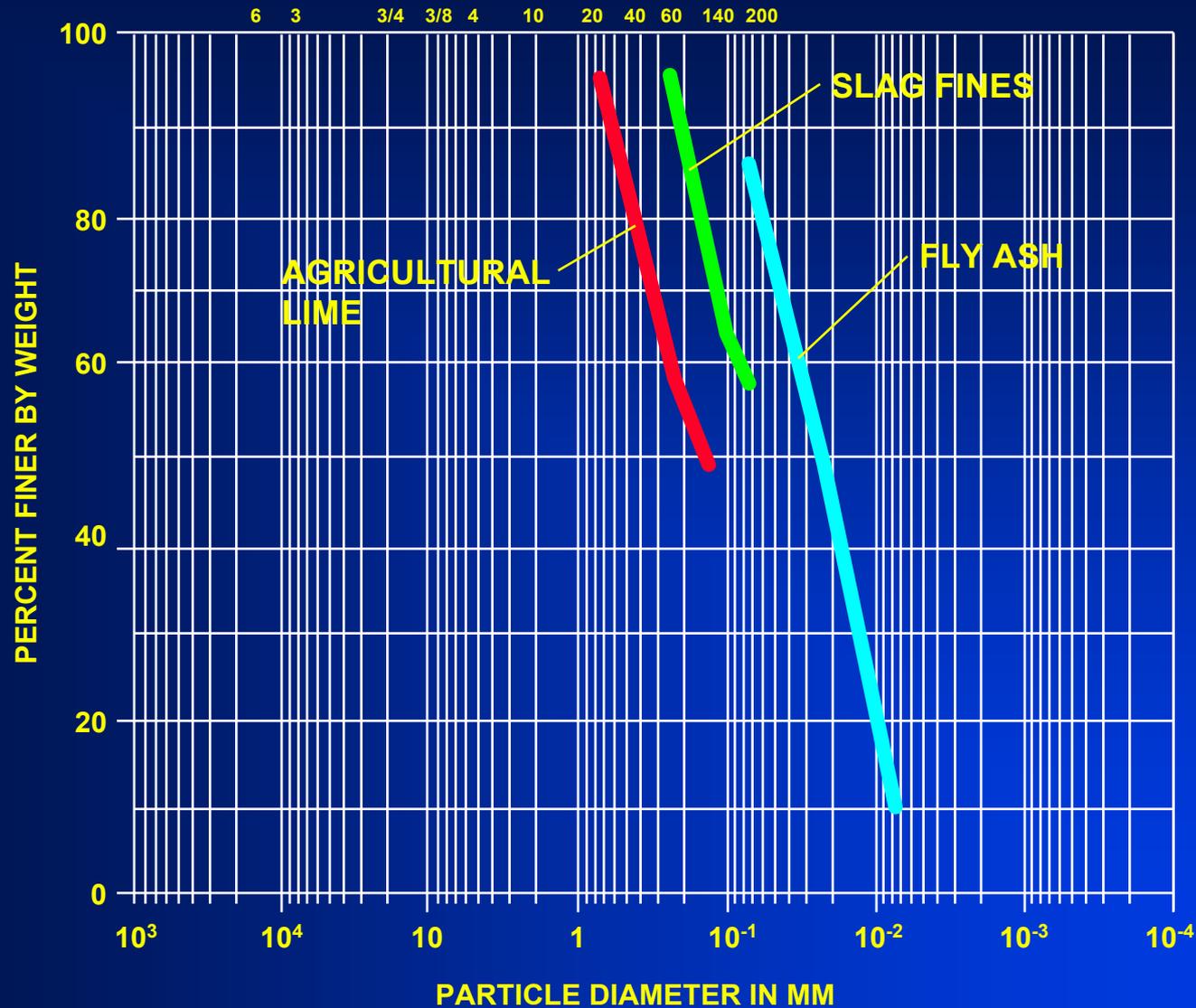
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Technology Conference

# SLAG vs. FLY ASH COMPOSITION

Constituent	Composition (%)	
	Slag	Fly Ash
CaO	40 - 52	2 - 26
SiO <sub>2</sub>	10 - 19	25 - 50
Al <sub>2</sub> O <sub>3</sub>	1 - 10	10 - 35
Fe <sub>2</sub> O <sub>3</sub>	3 - 20	7 - 11
Mn <sub>2</sub> O <sub>3</sub>	5 - 8	
MgO	5 - 10	1 - 7
S	< 0.1	0 - 4

# GRAIN SIZE COMPARISON



# INFORMATION ON RECMIX OF PA

- Recmix Processes Stainless Steel Slag to Produce Two Products
  - Stainless Steel Chips – Sold Back to Steel Producers
  - Reclime – Used as Agricultural Lime, Mine Buffering Material and Engineered Fill
- Recmix Processes Slag in:
  - Sarver, PA – 700,000 Tons Annually
  - Ghent, KY – 300,000 Tons Annually

# SUMMARY OF TOTAL METAL DATA

Parameter	2000 95% UCLM Data	Typical Background (1)
Aluminum	20,407	10,000 – 300,000
Arsenic	0.99	0.1 - 40
Barium	93	10 – 5,000
Boron	114	2 - 270
Cadmium	5	0.01 – 2
Calcium	281,707	7,000 – 500,000
Chromium	1,896	1 – 2,000
Copper	47	2 – 250
Iron	22,798	7,000 – 550,000
Lead	12	2 – 300
Magnesium	66,511	NE
Manganese	7,759	20 – 10,000
Mercury	0.05	0.01 – 0.5
Molybdenum	56	0.1 – 40
Nickel	186	5 - 700

All Concentrations in milligrams per kilogram (mg/kg),  
Except CCE

CCE - Calcium Carbonate Equivalent (Percent)

UCLM - Upper Confidence Limit on the Mean of the  
Data

NE - Not Established

(1) Reference: Trace Elements In the Terrestrial  
Environment, Adriano

# SUMMARY OF TOTAL METAL DATA (CONTINUED)

Parameter	2000 95% UCLM Data	Typical Background (1)
Phosphorus	186	200 – 5,000
Potassium	367	400 – 30,000
Selenium	6.85	0.01 - 12
Silicon	151,205	230,000 – 350,000
Silver	5	0.01 – 8
Sodium	626	750 – 7,500
Sulfur	1,841	NB
Titanium	2,370	150 – 25,000
Zinc	70	1 – 900
CCE:		
Calculated	97.8	NB
Titrated	102.3	NB

All Concentrations in milligrams per kilogram (mg/kg), Except CCE  
 CCE - Calcium Carbonate Equivalent (Percent)  
 UCLM - Upper Confidence Limit on the Mean of the Data  
 NB - No Background Concentration Available  
 (1) Reference: Trace Elements In the Terrestrial Environment, Adriano

# TOTAL METAL COMPARISON RECLIME VS. FLYASH

RCRA METALS	TOTAL METALS (MG/KG)
ARSENIC	 RECMIX (0.99) FLYASH (6-1200)
BARIUM	 RECMIX (93) FLYASH (100-1074)
CADMIUM	 RECMIX (5) FLYASH (0.29-51)
CHROMIUM	 RECMIX (1896) FLYASH (15-900)
LEAD	 RECMIX (12) FLYASH (11-800)
MERCURY	RECMIX (0.05) FLYASH (NOT ANALYZED)
SELENIUM	 RECMIX (6.85) FLYASH (7-760)
SILVER	RECMIX (5) FLYASH (ND <1)

# SUMMARY OF TCLP DATA

Parameter	2000 95% UCLM Data	Drinking Water Standards (1)
Aluminum	0.064	0.200(2)
Arsenic	0.005	0.05
Barium	0.410	2.0
Cadmium	0.0025	0.005
Chromium	0.125	0.10
Copper	0.006	1.00(2)
Iron	0.019	0.300(2)
Lead	0.006	0.015(3)
Manganese	0.005	0.050(2)
Mercury	0.0001	0.002
Molybdenum	0.299	NE
Nickel	0.005	0.100
Selenium	0.034	0.05
Silver	0.010	0.1(2)
Zinc	0.006	5.0(2)

All Concentrations in mg/l

UCLM - Upper Confidence Limit on the Mean of the Data

(1) Maximum Contaminant Level (MCL), Except when otherwise noted

(2) Secondary MCL

(3) Advisory limit for Tap Water

NE - Non Established

NA - Not Analyzed

# TCLP METAL COMPARISON RECLIME VS. FLYASH

RCRA METALS	TCLP METALS (MG/L)
ARSENIC	▼ RECMIX (0.005)  FLYASH (0.005-0.317) ▲ DRINKING WATER STANDARD (0.05)
BARIUM	▼ RECMIX (0.410)  FLYASH (0.077-0.819) ▲ DRINKING WATER STANDARD (2.0)
CADMIUM	▼ RECMIX (ND 0.0025)  FLYASH (0.050-0.287) ▲ DRINKING WATER STANDARD (0.005)
CHROMIUM	▼ RECMIX (0.125)  FLYASH (0.050-0.921) ▲ DRINKING WATER STANDARD (0.10)
LEAD	▼ RECMIX (0.006)  FLYASH (0-0.250) ▲ DRINKING WATER STANDARD (0.015)
MERCURY	RECMIX (ND <0.0001) FLYASH (ND <0.0002) DRINKING WATER STANDARD (0.002)
SELENIUM	▼ RECMIX (0.034)  FLYASH (0.005-0.135) ▲ DRINKING WATER STANDARD (0.05)
SILVER	RECMIX (ND 0.010) FLYASH (ND <0.020) DRINKING WATER STANDARD (0.10)

# SLAG USES FOR RECLAMATION

1. BUFFERING AGENT
2. AMD TREATMENT
3. LOW PERMEABILITY LINING AND CAPPING MATERIAL
4. SOIL SUBSTITUTE FOR COVER
5. MINE GROUTING
6. LIMING AGENT FOR REVEGETATION
7. ENGINEERED FILL