

Nuevas tecnologías en Cemento

Camino a la Innovación



Inspección de hormigón: Alternativas
Evaluación y Solución de Problemas
10 noviembre 2005



Temas

- ◆ Tipos de Cemento utilizados en PR
- ◆ Introducción Cemento Slag
- ◆ Procedencia, proceso, características,
- ◆ Usos y proporciones
- ◆ Beneficios
- ◆ Flexibilidad de diseño



Tipos de Cemento en Nuestra Isla

Cemento Tipo I

Uso General

Cemento Tipo II

Moderada Resistencia Sulfatos

Fly Ash (Ceniza) Tipo F

Permeabilidad y Durabilidad

Slag Cement 2005 

Historia Slag Cement

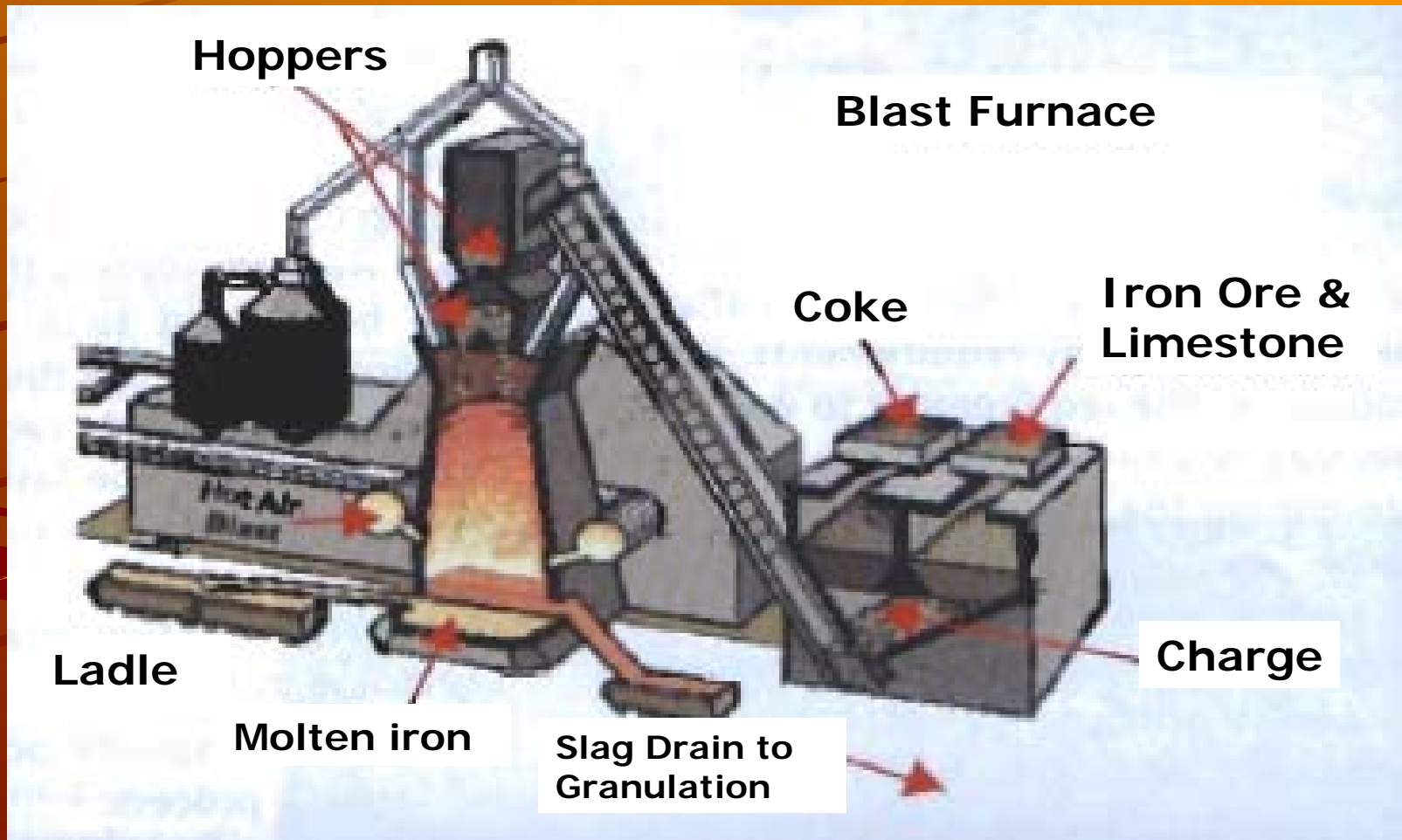
- 1700` s en Europa y Reino Unido
- 1896 primera producción en US en “blended cement” y como parte del proceso del clinker.
- 1950 Comienza el uso slag en otros países (nivel mundial)
- 1980 Se establece en EU la primera compañía Procesadora 100% Slag en Sparrows Point, Maryland

Procedencia del Slag

Manufactura de Hierro



Proceso de Producción



Tipos de Slag



-Enfriado al aire libre (Air Cooled Slag)
(Usado como agregado en hormigón)

APPLICATIONS

- CONCRETE
- ASPHALTIC PAVEMENT
- LIGHTWEIGHT EMBANKMENT
- WATERWAY APPLICATIONS
- MASONRY UNITS
- MINERAL WOOL
- SOIL CONDITIONING
- METALLURGICAL FLUX
- GLASS MAKING

AREAS OF ADDED VALUE

- Excellent paste - aggregate bond in concrete
- Greater yield for all construction applications
- Improved skid resistance and stability in asphaltic pavements
- High angle of internal friction resulting in improved aggregate interlock
- Lower unit weight/Improved engineering properties for light-weight embankment
- Improved fire resistance for masonry and concrete applications
- Lower freight and labor costs due to lower unit weight
- Replenished soil with mineral and pH balance
- Economical alternative to Wollastonite as key ingredient in metallurgical mold powders and flux products
- Physical and chemical suitability for mineral wool production

Tipos de Slag



- Enfriado a con agua o vapor de agua
(Expanded Slag)
(Usado como agregado liviano en hormigón)

APPLICATIONS

- MEDIUM TO LIGHTWEIGHT CONCRETE MASONRY UNITS
- LIGHTWEIGHT EMBANKMENT
- MEDIUM TO LIGHTWEIGHT STRUCTURAL CONCRETE

AREAS OF ADDED VALUE

- Expanded blast furnace slag aggregate is a specialty product made for the masonry block industry.
- Masonry units containing expanded blast furnace slag aggregate possess many desirable properties such as reduced weight, improved sound absorption and excellent thermal properties.
- Substantial improvements in

labor efficiencies can also be realized as masons can handle and place more lower weight units per day.

- Improvements in fire resistance ratings have also been documented for masonry and structural concrete units made from expanded blast furnace slag aggregate, as documented in the above table representing the findings of the American Insurance Association.

Tipos de Slag



-Enfriado extremo (Granulated Slag)
(Usado como slag cement GGBS)

GENERAL APPLICATIONS

- RAW MATERIAL FOR THE MANUFACTURE OF CEMENT
- LIGHTWEIGHT FILL
- RAW MATERIAL FOR THE MANUFACTURE OF GLASS

FACTORS AFFECTING

CEMENTITIOUS PROPERTIES

- Chemical composition of GGBF slag
- Alkali concentration of the reacting system
- Glass content of the GGBF slag
- Fineness of the GGBF slag and portland cement

AREAS OF ADDED VALUE

GGBF SLAG SPECIALTY

CONCRETE APPLICATIONS

- Reduced chloride permeability
- Improved resistance to sulfate attack
- Reduced heat of hydration in mass concrete
- Improved compressive and flexural strength
- Reduced alkali-silica reaction

Usos del Slag

BF Air-Cooled	BF Expanded	BF Granulated	Steel Slag
Asphalt aggregate	Concrete masonry	GGBS cement	Asphalt aggregate
Concrete aggregate	Lightweight concrete	Soil cement	Railroad ballast
Insulation/mineral wool	Lightweight fill	Roller compacted concrete	Cement raw feed
Cement raw feed	Insulation		Agriculture
Agriculture			Environmental App.
Fill			
Roof aggregate			
Railroad ballast			
Glass manufacture			
Environmental App			

Composición Química

Typical Chemical Constituents

	Percent		Percent
Silica (SiO ₂)	32-42	Sulfur (S)*	1-2
Alumina (Al ₂ O ₃)	7-16	Iron Oxide (Fe ₂ O ₃)	1-1.5
Calcium (CaO)	32-45	Manganese Oxide	0.2-1.0
Magnesia (MgO)	5-15	(MnO)	

Composición Química

Table 1: Typical Chemical Oxides for Various Cementitious Materials

	Portland Cement	Slag Cement	Fly Ash C	Fly Ash F
CaO	65	45	25	3
SiO ₂	20	33	37	58
Al ₂ O ₃	4	10	16	20
Fe ₂ O ₃	3	1	7	10
MgO	3	6	7	1



Figure 1: Ternary diagram of cementitious materials

Composición Química

TYPICAL PHYSICAL PROPERTIES	GGBS	PORTLAND CEMENT
<i>Colour</i>	Off white	Grey
<i>Relative density</i>	2.9	3.15
<i>Bulk density, kg/m³</i>	1200	1400



Propiedades Químicas Añadidas

- Resistencia a Ataques de Sulfatos
- Resistencia a la Penetración de Cloruros (Bajas Permeabilidades)
- Resistencia a Reacciones Silica-Alcalinas
- Disminuye el Calor de Hidratación
- Extiende el fragüe inicial

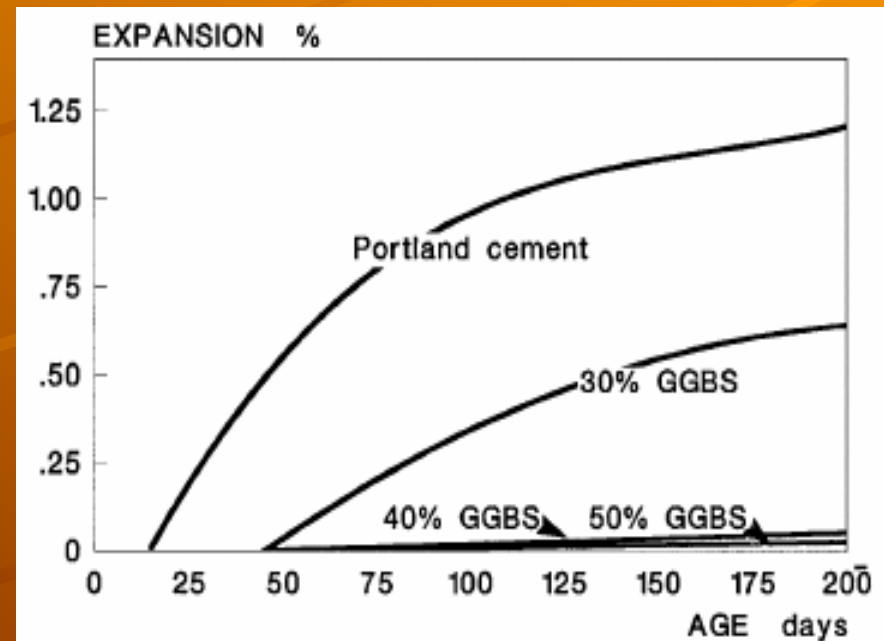
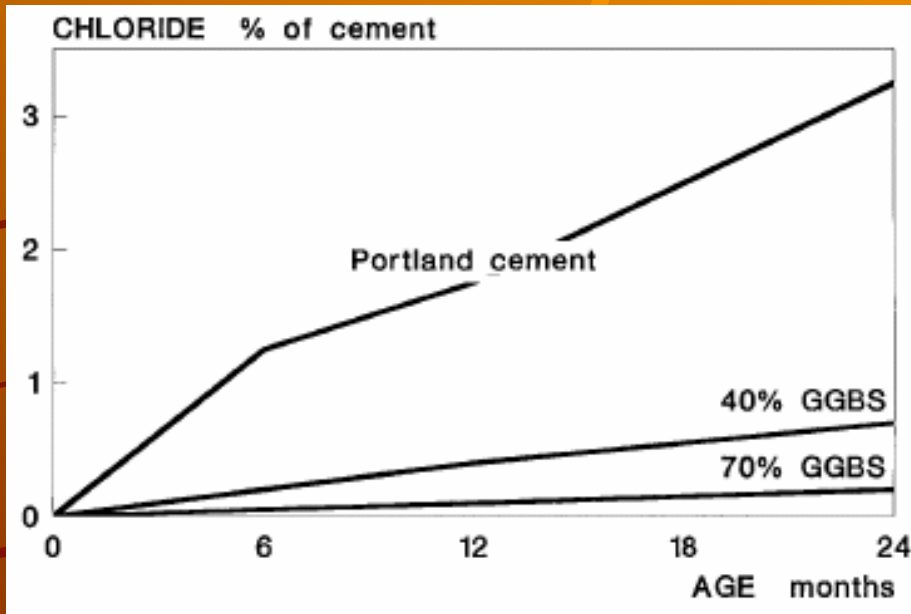


Propiedades Físicas Añadidas

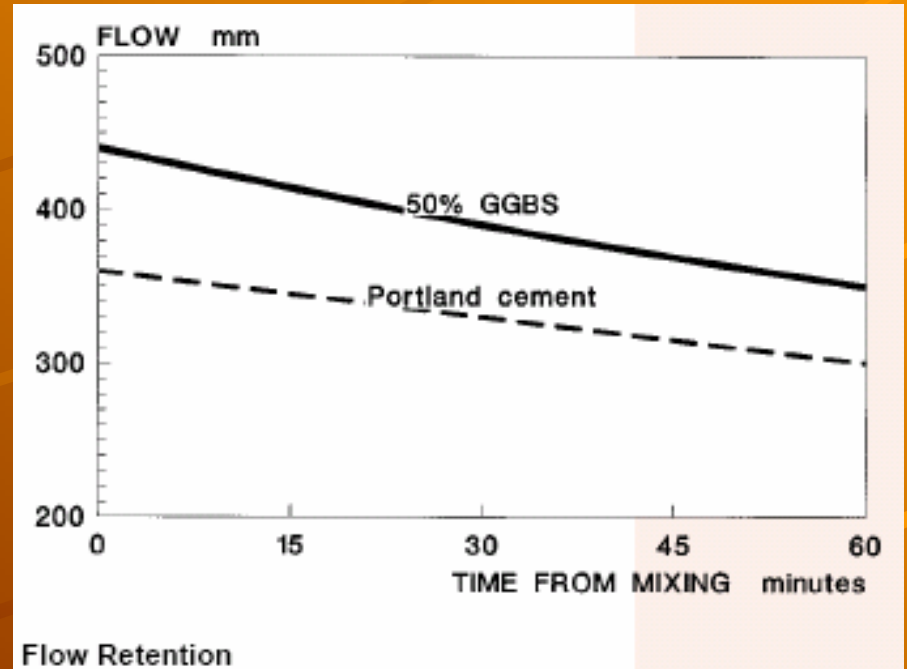
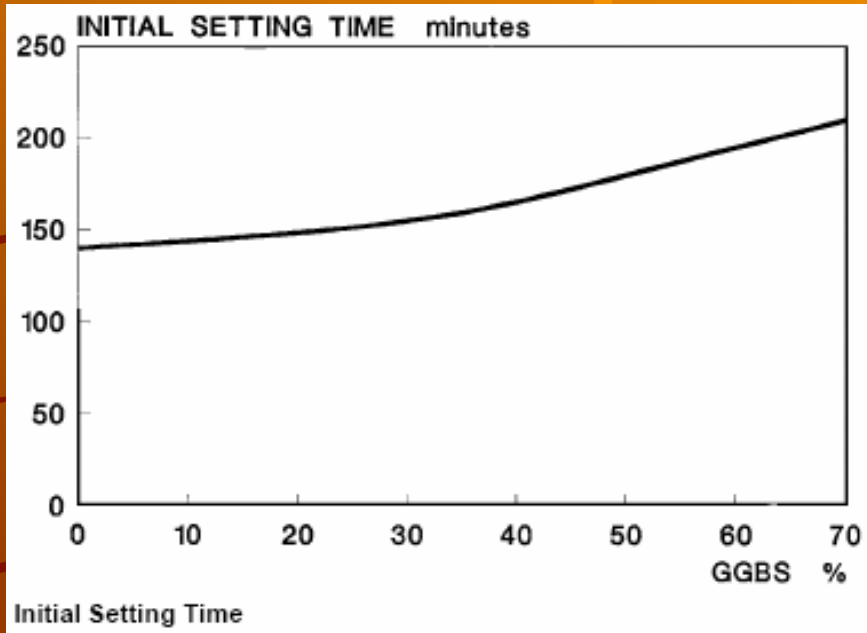
- Mayor consistencia en su estado plástico y endurecido
- Concretos de Mejor Manejabilidad
- Resistencia a Altas Temperaturas
- Mejores resultados en compresión y flexión
- Color más claro



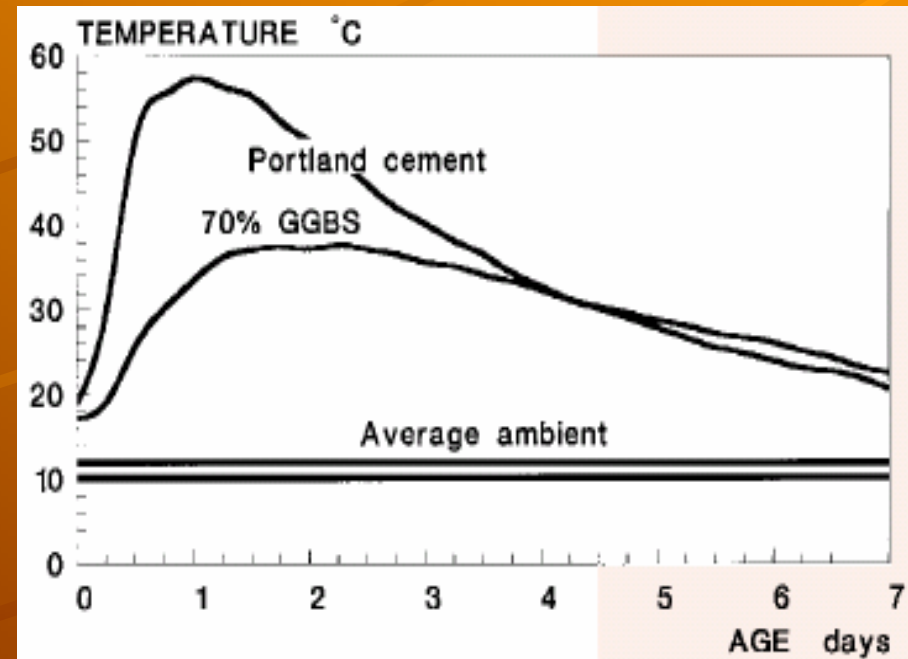
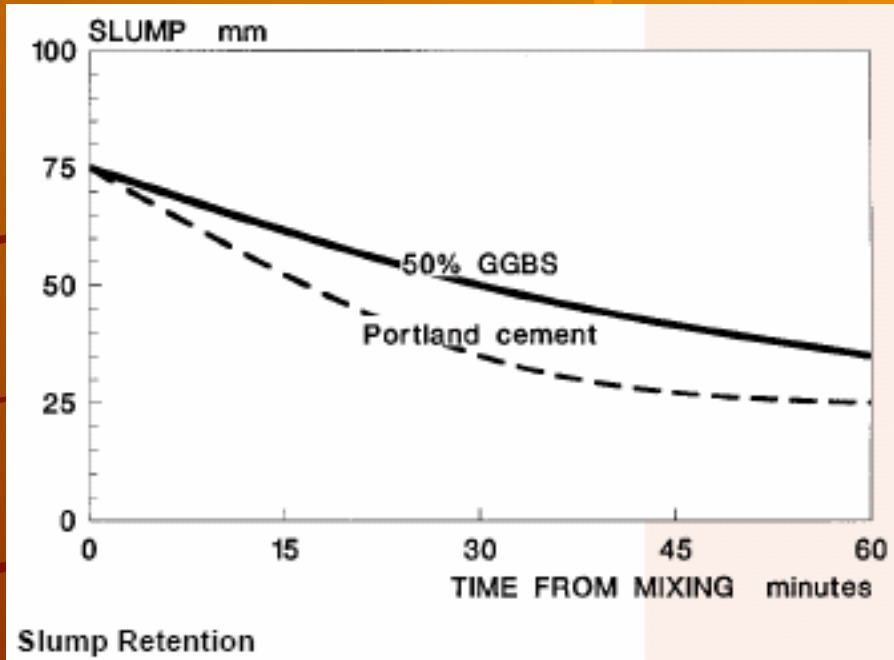
GRAFICOS



GRAFICOS



GRAFICOS



Porcentajes según Aplicación

Concrete Application	Slag Cement
Concrete paving	25-50%
Exterior flatwork not exposed to deicer salts	25-50%
Exterior flatwork exposed to deicer salts with $w/cm \leq 0.45$	25-50%
Interior flatwork	25-50%
Basement floors	25-50%
Footings	30-65%
Walls & columns	25-50%
Tilt-up panels	25-50%
Pre-stressed concrete	20-50%
Pre-cast concrete	20-50%
Concrete blocks	20-50%
Concrete pavers	20-50%
High strength	25-50%
ASR mitigation	25-70%
Sulfate resistance	
Type II equivalence	25-50%
Type V equivalence	50-65%
Lower permeability	25-65%
Mass concrete	50-80%

Percentages indicate replacement for portland cement by mass. These replacement rates are

FOR GENERAL USE

Cementitious Materials

1. Portland cement shall conform to the requirements in ASTM C-150¹ or ASTM C-1157².
2. Slag cement shall conform to the requirements in ASTM C-989³.
3. Blended cement shall conform to the requirements in ASTM C-595⁴.
4. Pozzolans shall conform to the requirements in ASTM C-618⁵.
5. Silica fume shall conform to the requirements in ASTM C-1240⁶.
6. The water-cementitious materials ratio (W/CM) shall be calculated by dividing the weight of water by the weight of portland cement, plus slag cement plus pozzolans.

Beneficios

- ◆ Estructuras más duraderas
- ◆ Reducción de costos por reparación y/o mantenimiento
- ◆ Mayor resistencia a cloruros
- ◆ Mayor resistencia a sulfatos
- ◆ Mayor resistencia en compresión y flexión



Beneficios

- ◆ Mayor manejabilidad en su estado plástico
- ◆ Mayor retención de “slump”
- ◆ Mejor colocación y terminación
- ◆ Mejor capacidad de almacenaje
- ◆ Mayor flexibilidad de diseño



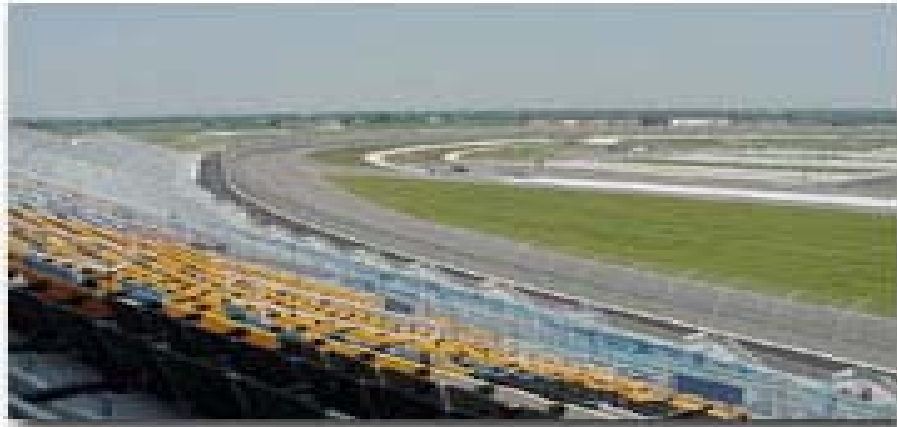
Proyectos



Sky Dome, Toronto, Canada



Rock and Roll Hall of Fame and Museum,
Cleveland, Ohio.



Proyectos

Reduced Chloride Permeability



Baltimore-Washington International Airport
Parking Structure.

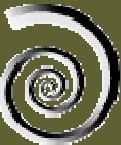

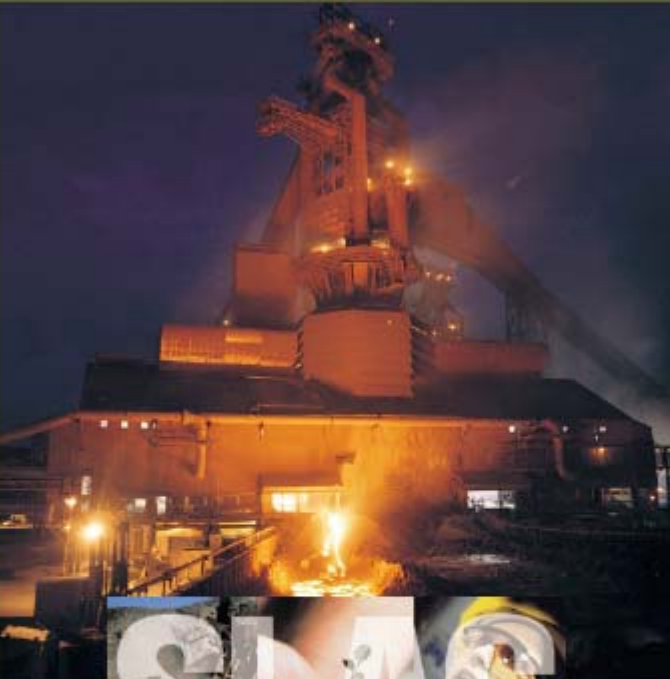
Reduced Heat of Hydration



Mass Concrete: Sylvan Lake Dam, stilling basin,
Rome City, IN

PREGUNTAS ?????

B L A S T F U R N A C E S L A G



The
Construction
Material
of Choice



Gracias por su atención.