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Use of acidic slags as constituents of cements produced by Votorantim Cimentos in Brasil

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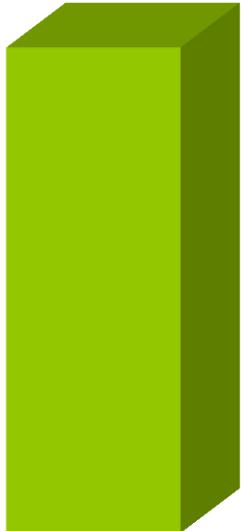
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Realização

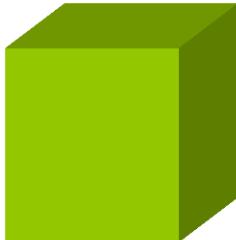


Votorantim Cimentos' clinker factor

The clinker content of the cements produced by Votorantim is decreasing constantly due to investments in R&D focused on the use of alternative clinker substitutes and on the production of pozzolan



1990

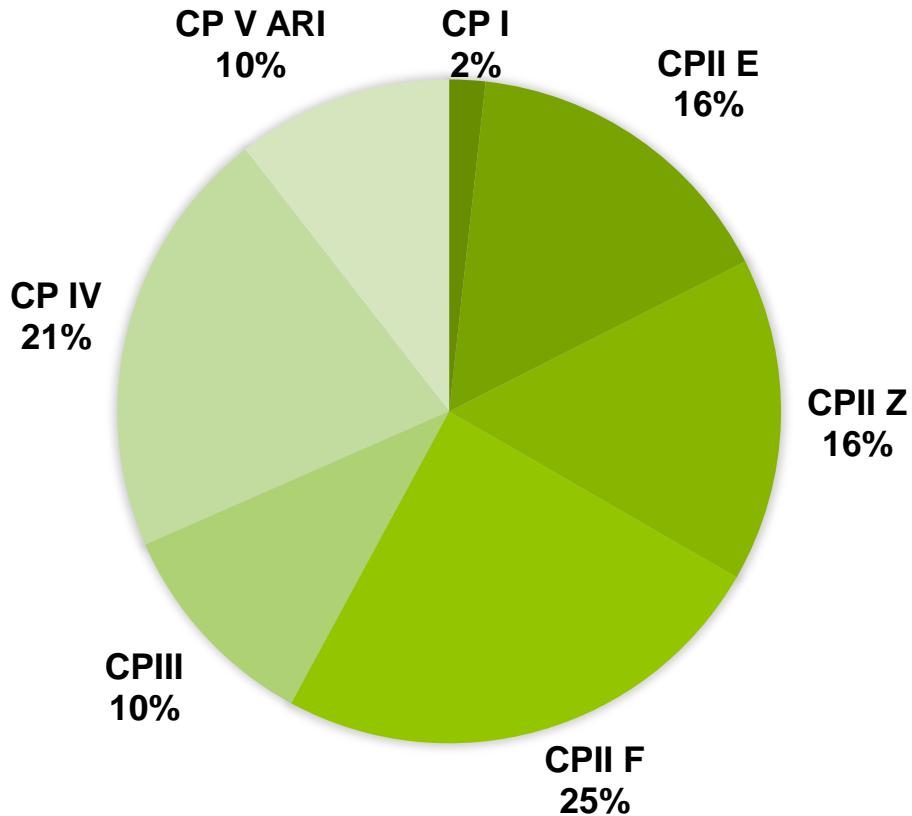


2015

The big challenge is to produce cements with lower clinker factor with performance well accepted by the customers

Use of SCM at Votorantim Cimentos

Votorantim Cimentos is market leader regarding the use of cementitious materials in Brazil



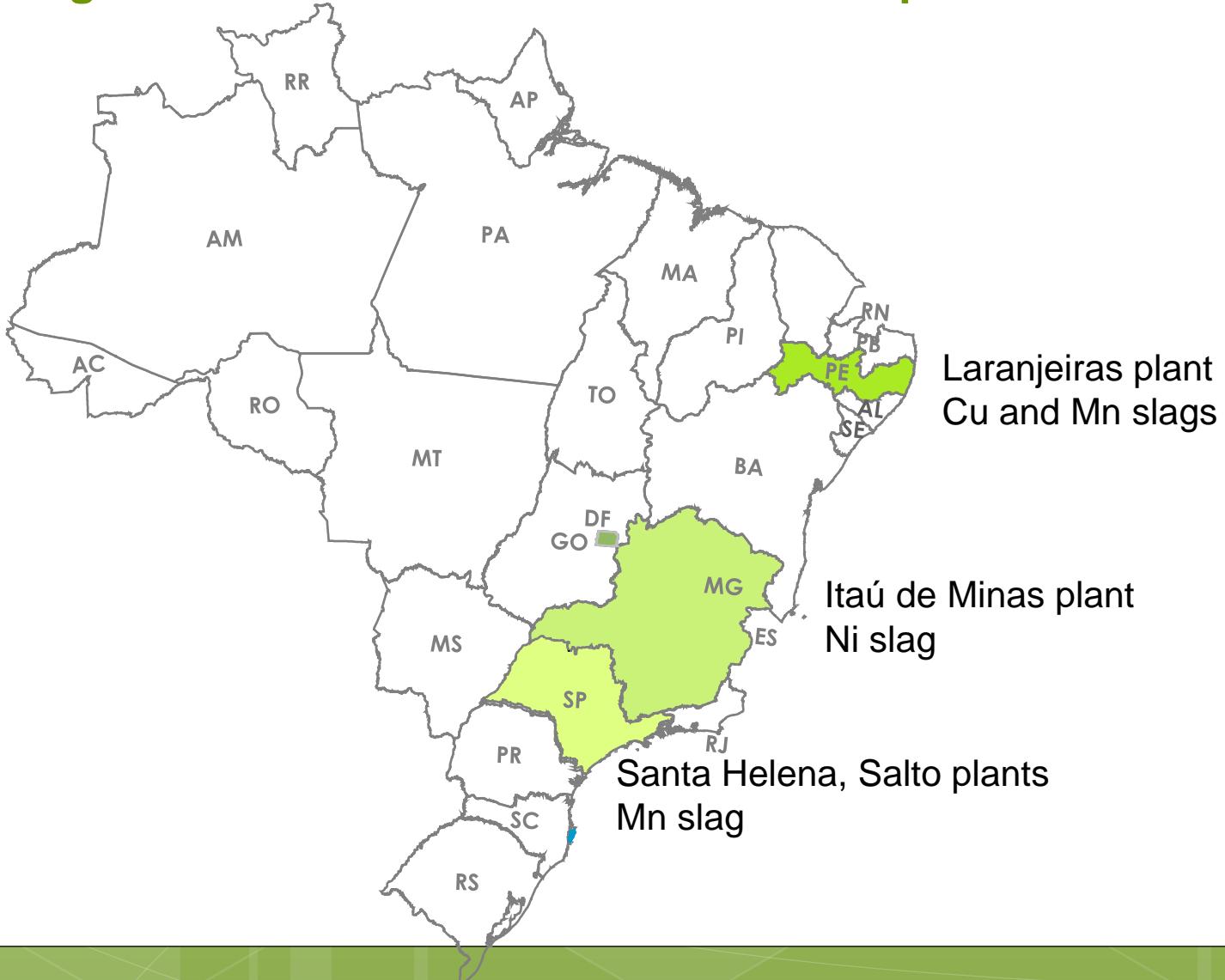
- In Brazil, every ton of steel generates 594 kg of by-products and residues. This is equivalent to 17 million tons
- The majority of this by-products are slags
- The use of acidic slag as SCM is still incipient: it is equivalent to, approximately 5% of the volume generated.



Acidic slag replaces clinker in pozolanic cements, according to the NBR 11578 and NBR 5736

Cement	Clinker + gypsum	Pozzolanic material	Limestone filler
Composite CP II-Z	76 - 94	6 - 14	6 - 10
Pozzolanic CP IV	45 - 85	15 - 50	0 - 5

Acidic slags are used at 4 Votorantim Cimentos plants as SCM



Acid slags used by Votorantim Cimentos as SCM

Nickel slag

- By-product from garnierite beneficiation (Ni ore) through a pyrometallurgic process
- Used as SCM at VC's Itaú de Minas plant since 2005 for production of CP II-Z

Copper slag

- The use of Cu slag as SCM started in 2007, at Laranjeiras plant, at NE of Brazil
- It is a result of the beneficiation of chalcopyrite and chalcocite in an electric furnace for production of metallic Cu

Manganese slag

- It has been used as SCM since 2013 in Votorantim Cimentos' plants located in the SE of Brazil

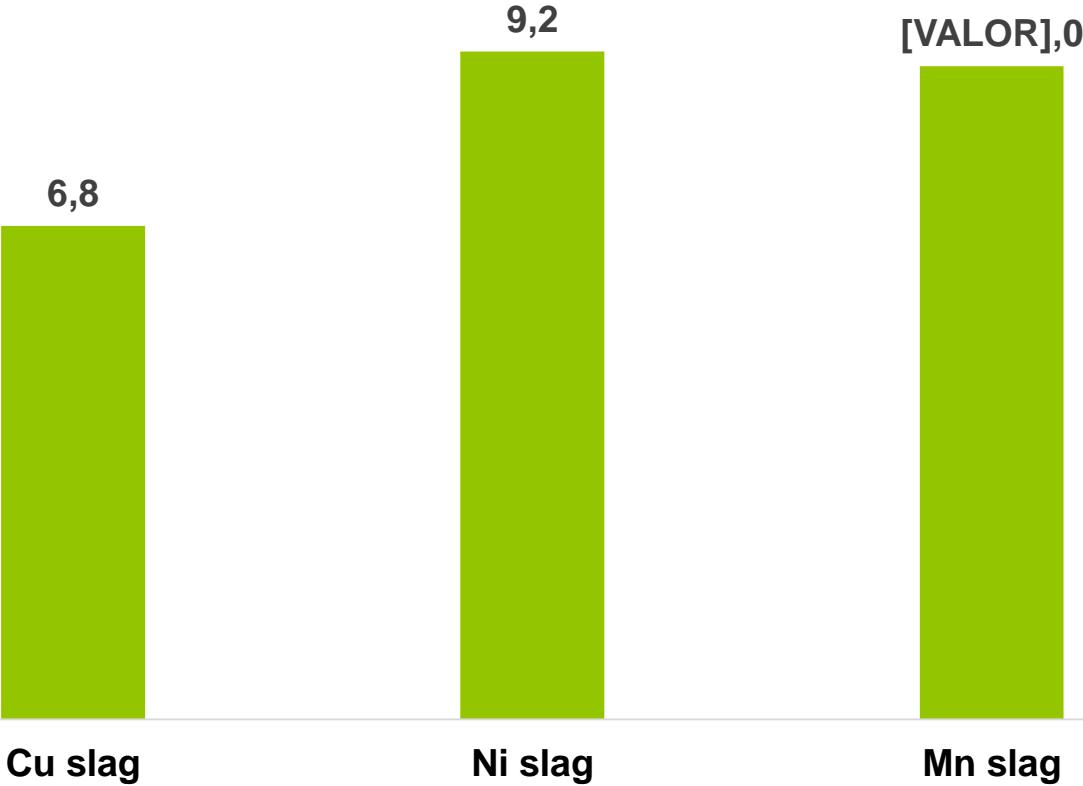
Characteristics of Cu, Ni and Mn slags

Parameters	Slag			Standard limits
	Cu	Ni	Mn	NBR 12653
$\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$ (% min)	91	68	60	> 50
SO_3 (% max)	1,1	0,05	0,9	< 5,0
LOI (% max)	0,0	1,2	0,0	< 6,0
Available alkalis as Na_2O (% max)	0,03	0,05	0,02	< 1,5

Cu, Ni, Mn slag

Pozzolanic activity index measured with lime at 7 days

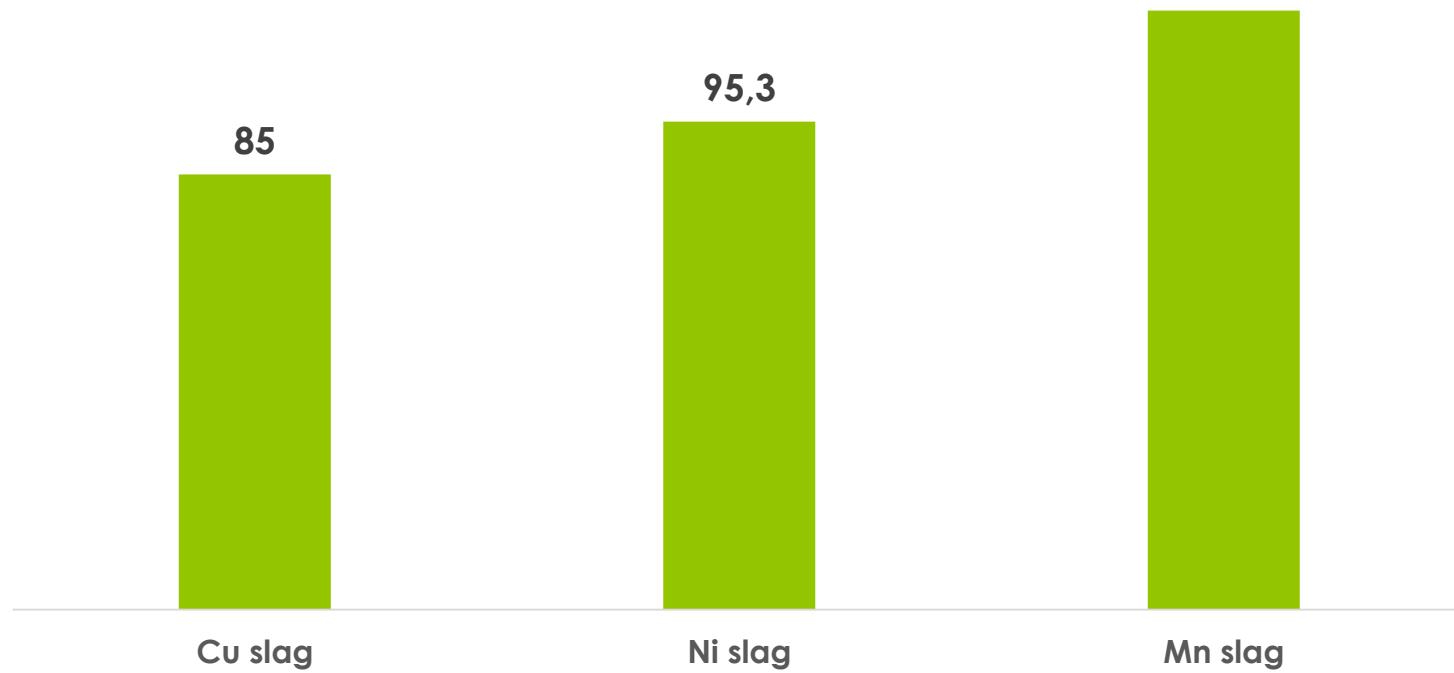
7 days compressive strength (MPa)



Cu, Ni, Mn slag

Pozzolanic activity index measured with cement at 28 days

28 days compressive strength (%)



Leaching

Tests were performed in samples of the slags

as received and in hardened cement pastes using these slags as partial cement replacement.

after accelerated carbonation, to simulate the pH modification due to the aging of the cementitious products.

The results prove that the Ni, Cu and Mn slags can be considered as inert, class II by-products according the Brazilian standard NBR 10004.

Sulfate resistance of cements with limestone filer and Ni slag

