STUDY OF THE INFLUENCE OF PORTLAND CEMENT ON THE PROPERTIES OF CONCRETE WITH FLY ASH

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ICSC15 The Canadian Society for Civil Engineering
International Construction Specialty Conference

University of British Columbia, Vancouver, Canada, June 8-10, 2015

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Introduction (1)

The use of mineral admixtures as substitute of cement in concrete is widely extended for various reasons. The reduction of doses of cement in the concrete mixtures reduce the material costs, decreases the pollution and helps solve the problem of the elimination of the "by-products".

Introduction (2)

- The microstructural changes motivated by the mineral admixtures should generate a more compact concrete and a reduction in the average size of the pores.
- This can contribute to the improvement of the mechanical properties and durability of concrete.

Introduction (3)

- The efficacy of the use of the mineral admixtures is complex, hard to generalize and depends on the availability of materials in the local markets.
- This is because of variations in the physical and chemical properties of the mineral admixtures and the cements employed despite their classification under the same standard.

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Motivation

Metha establishes that is too early to predict a future of the corrosion inhibitors, reinforcement bars coated with epoxy, superficial caps layers and cathodic protection, due to the fact that when compared to concretes with fly ash or slag, the high costs of the firsts and environmental damaging are clearly an important disadvantage.

Fernández Cánovas argue that the most appropriate way to protect the reinforcement bars is to place good quality concrete.

Objective

- The effects of fly ash in concrete are widely known, but the effects of fly ash when used with the cements available locally are unknown.

- In Puerto Rico there are three brands of cement type I commercially available. All of them comply with the specifications of ASTM C150. All of them are classified type I, each one has different chemical and physical properties.

Objective

The main objective of the work is to better understand the influence of the durability and mechanical properties of concrete of each type of Portland cement when a partial substitution of fly ash is introduced.

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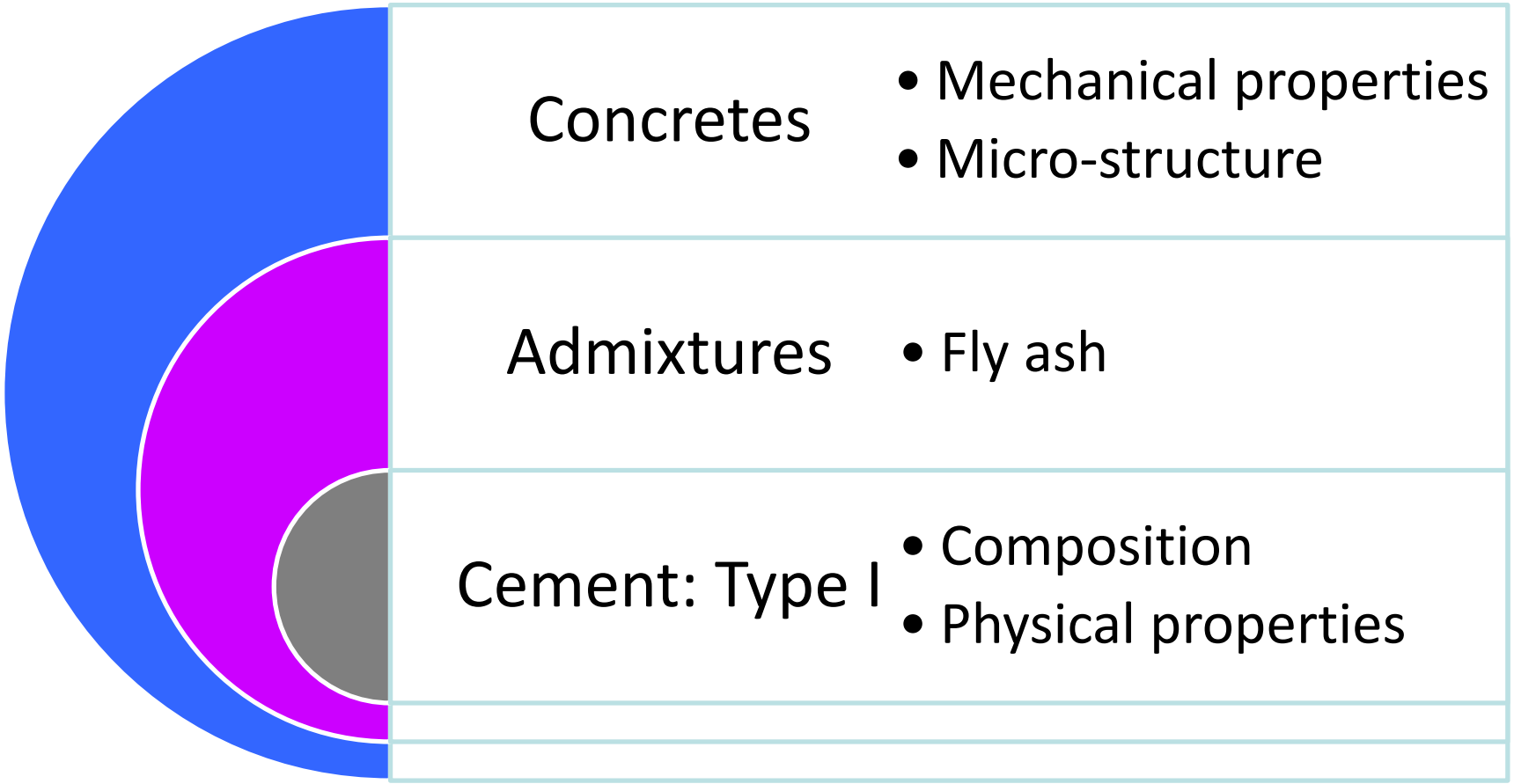
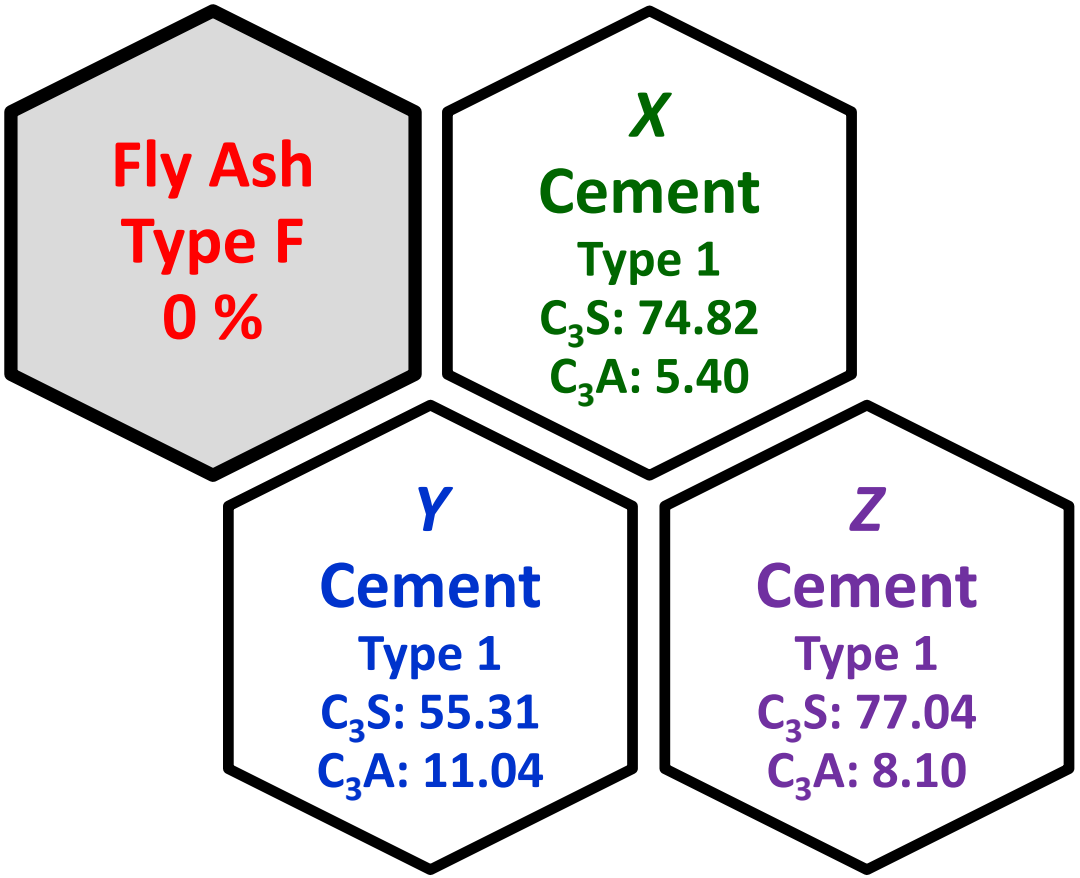
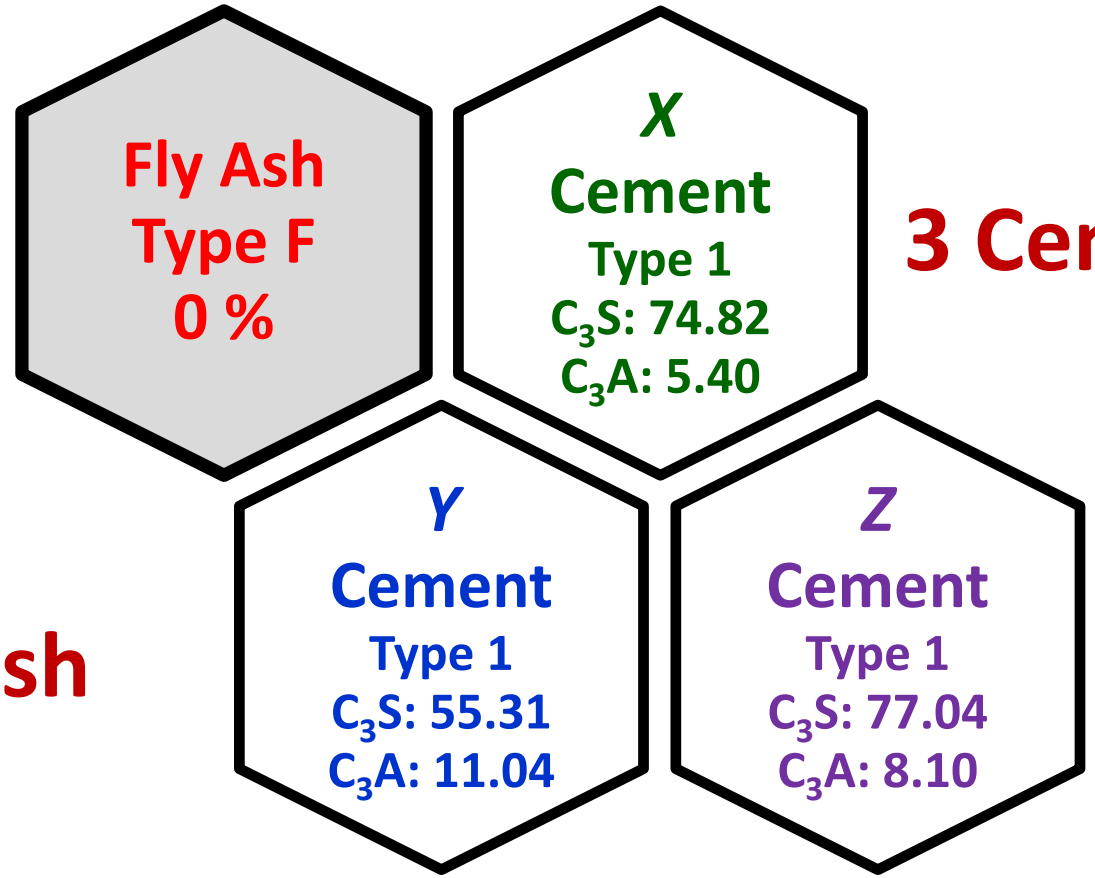
General Picture



Work Plan: Reference



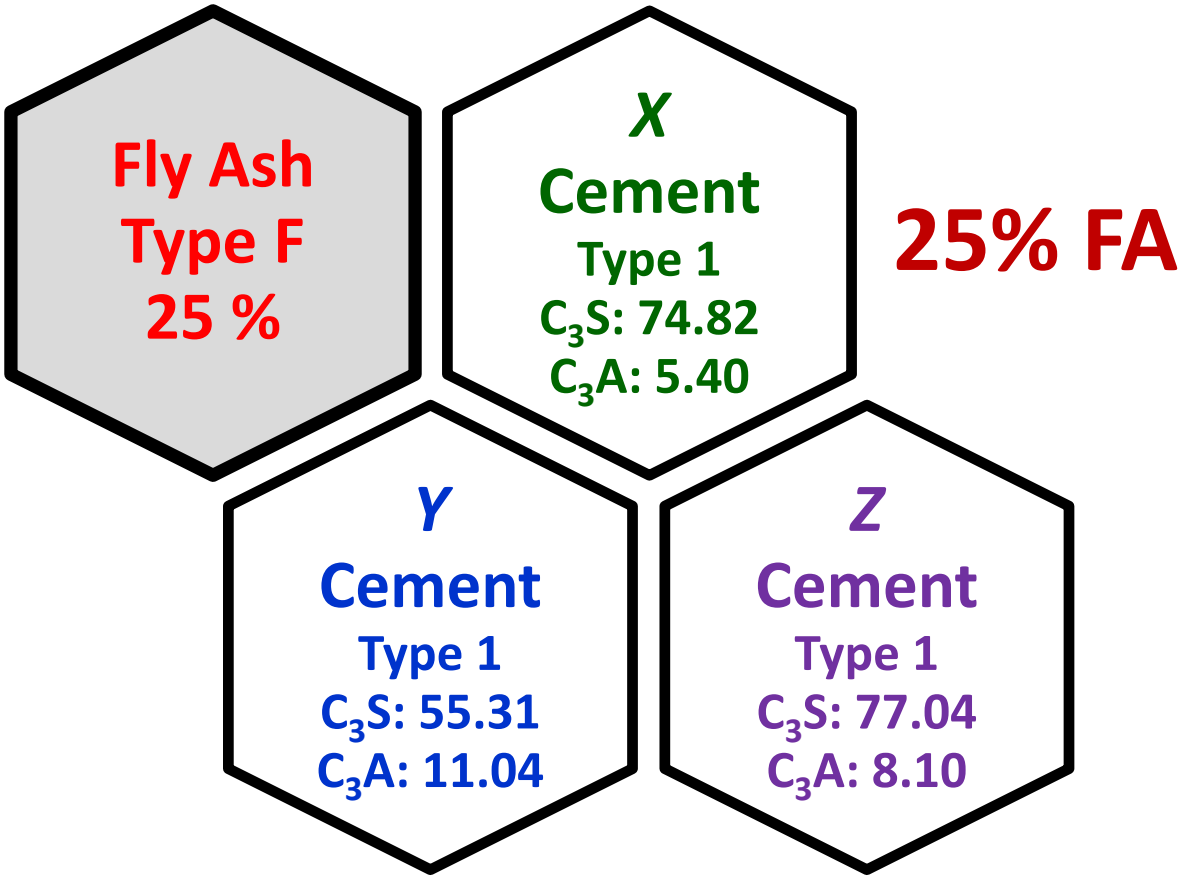
Work Plan: Reference



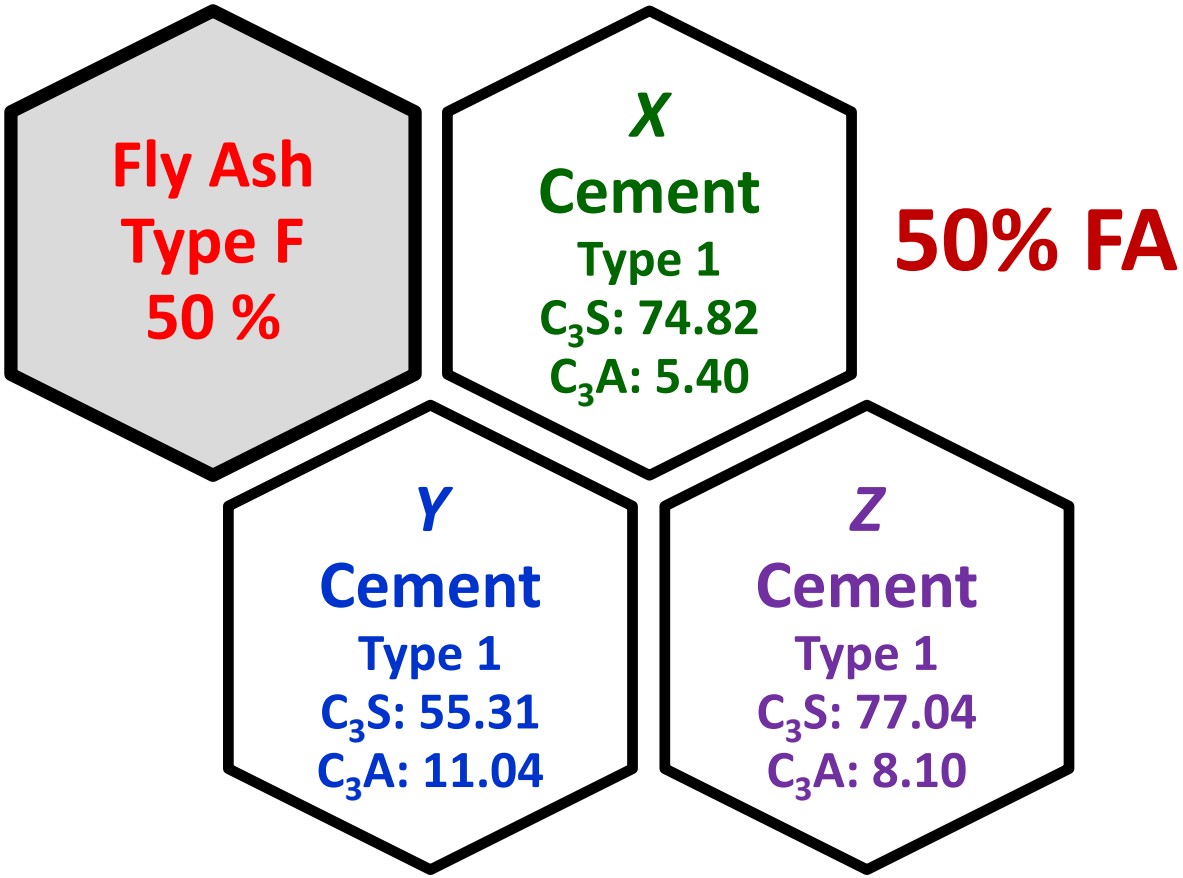
3 Cements

1 Fly ash

Work Plan: Experimental 1



Work Plan: Experimental 2



Work Plan: Analysis

Micro-structure

- Pore's structure
  - Mercury Intrusion Porosimetry
- Durability
  - Rapid Chloride-ion Permeability Test
  - Air Permeability

Mechanical properties

- Compressive strength test

Dosages by cubic meter of concrete

Mixture	Cement (kg)	Fly ash (kg)	Water (kg)	Coarse Aggregate (kg)	Fine Aggregate (kg)
Ref (0% Fly ash)	426.6	0.0	277.3	992.4	661.6
25% Fly ash	319.9	106.7	277.3	992.4	661.6
50% Fly ash	213.3	213.3	277.3	992.4	661.6

Tests completed

Tests	Time Period (days)				Standards
	28	91	160	280	
Compressive Strength	X	X	X	X	ASTM C39 – 05
Mercury Intrusion Porosimetry (MIP)	X		X	X	ASTM D4404 – 10*
Rapid Chloride-ion Permeability Test (RCPT)			X		ASTM C1202 – 09
Air Permeability			X		UNE 83966

* Adjusted experimentally

Methodology

Compressive strength test

Cement *X*, 25% FA

Cement *Y*, 25% FA

Cement *Z*, 25% FA

Methodology

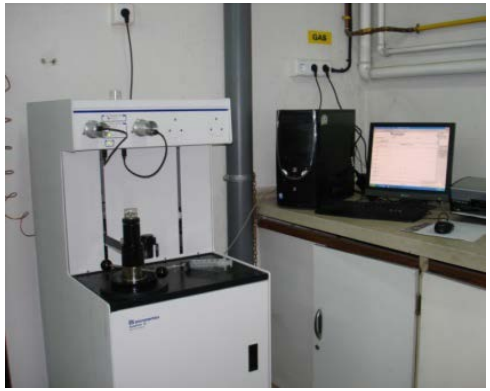
Rapid Chloride-ion Permeability Test (RCPT)

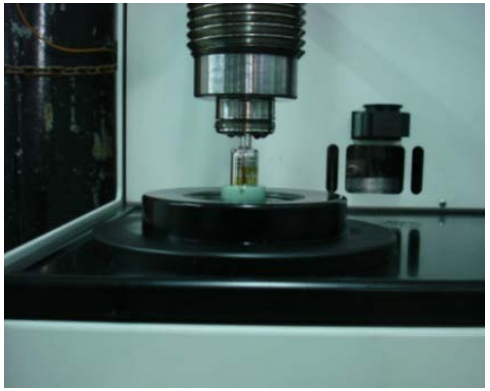
Sample

Equipment

Methodology

Mercury intrusion porosimetry





Fuente Molina 2008 [D]

Methodology

Air permeability

Fuente Al –Assadi 2009 [w]

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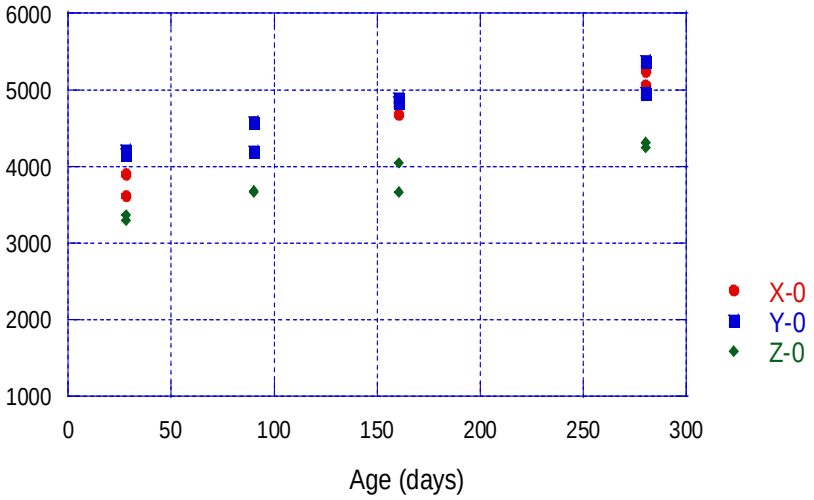
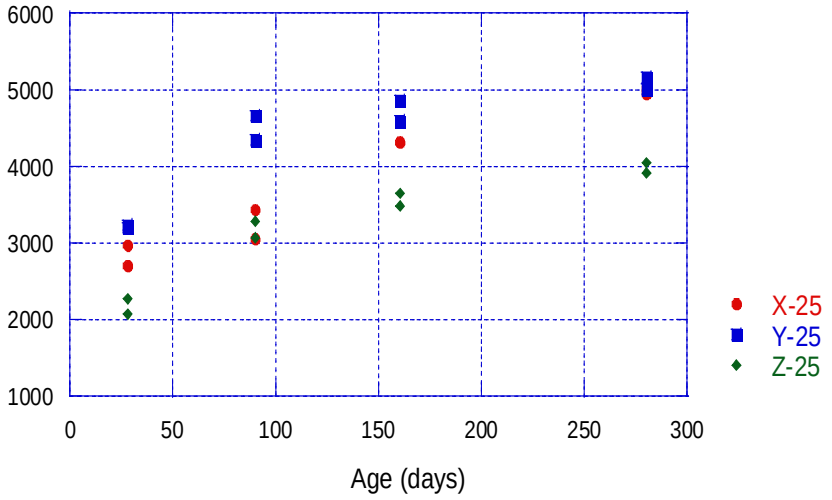
Results (1)

Compressive Strength (psi)

Concretes: *0% FA*



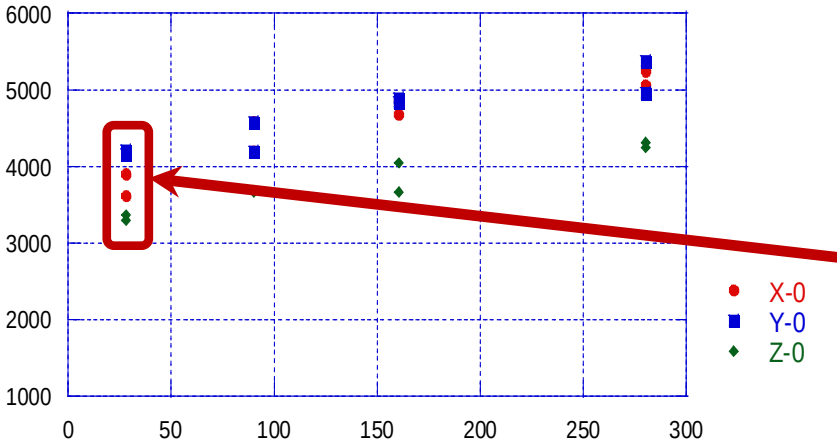
Concretes: *25% FA*



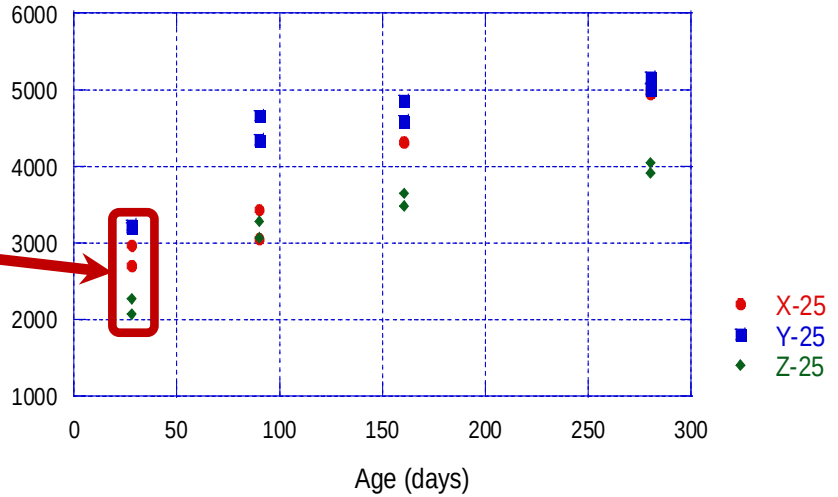
Results (1)

Compressive Strength (psi)

Concretes: *0% FA*



Concretes: *25% FA*

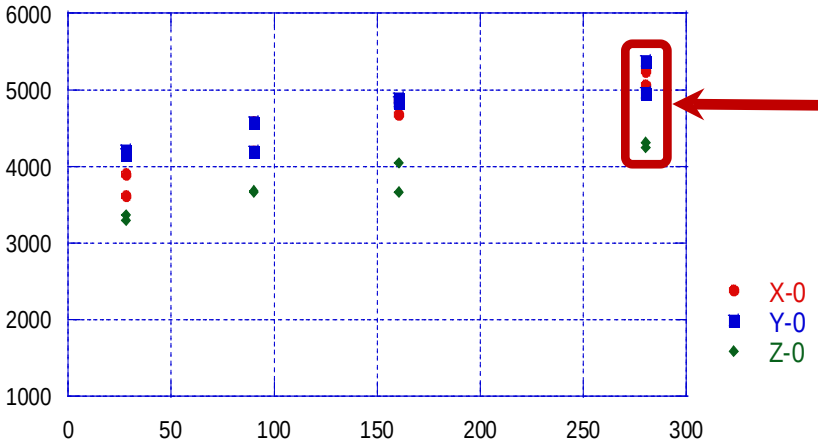


At early ages, the reference concretes show higher compressive strength than concretes with fly ash substitution.

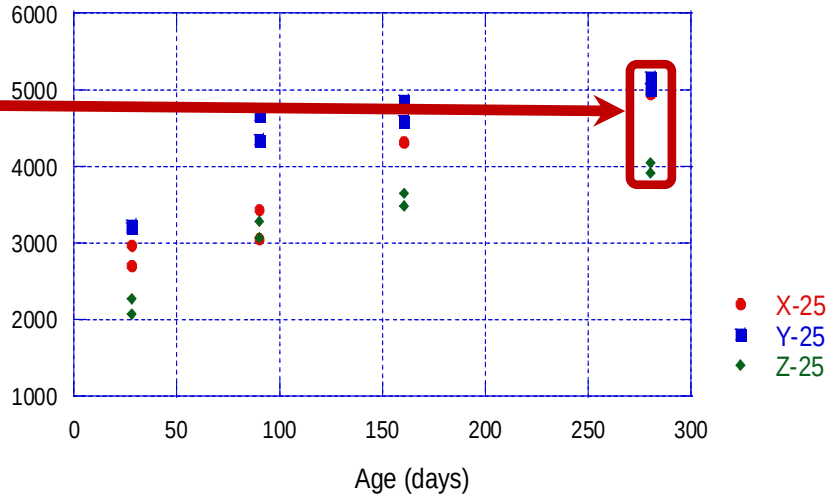
Results (2)

Compressive Strength (psi)

Concretes: *0% FA*



Concretes: *25% FA*

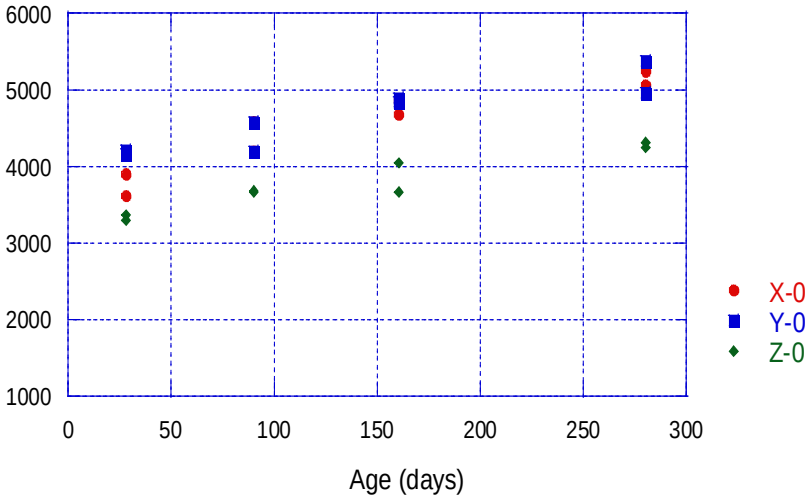


Concretes with 25% of fly ash substitution reach the values of compressive strength of the reference concretes as time progresses.

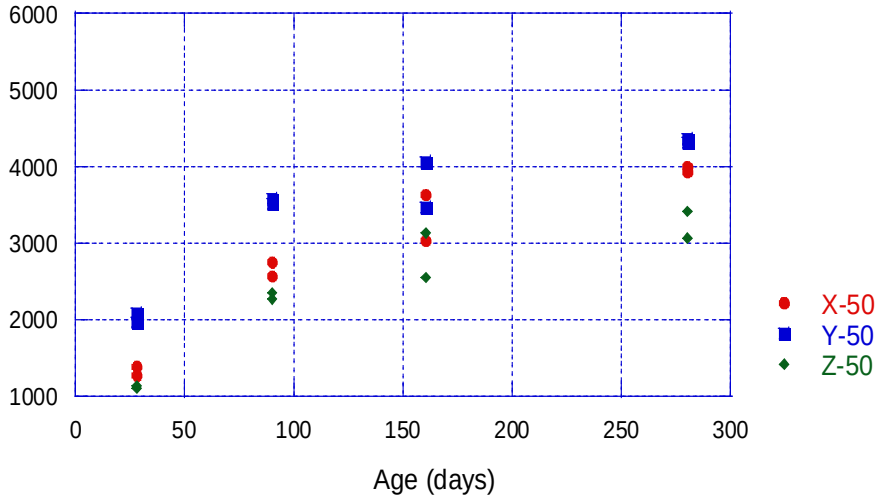
Results (3)

Compressive Strength (psi)

Concretes: *0% FA*



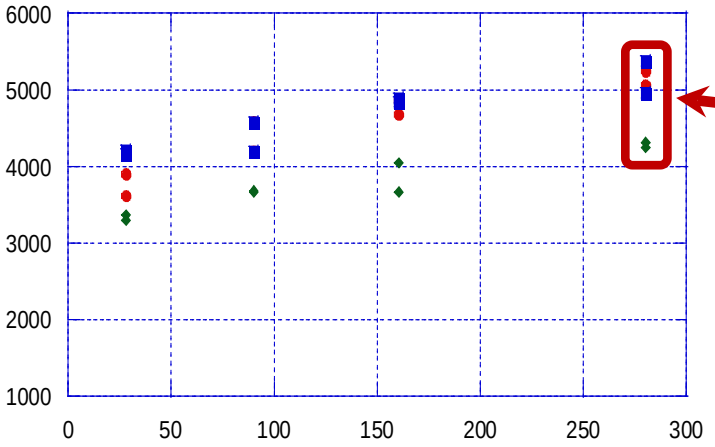
Concretes: *50% FA*



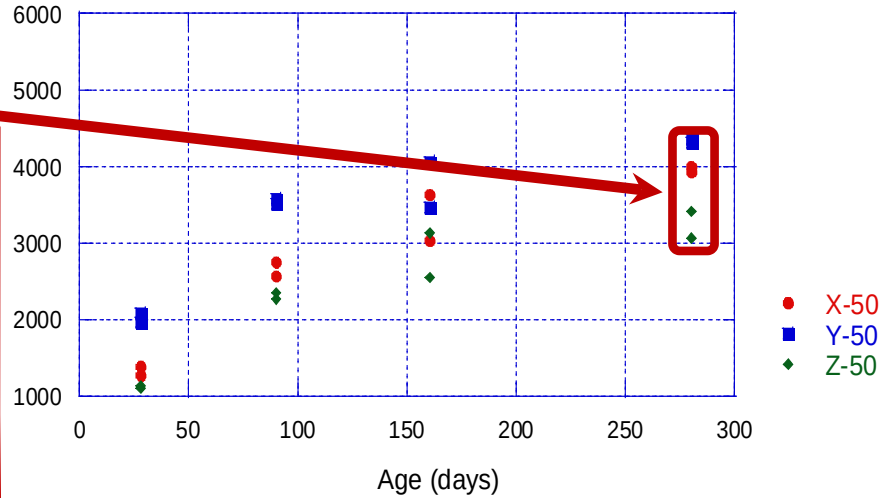
Results (3)

Compressive Strength (psi)

Concretes: *0% FA*



Concretes: *50% FA*



Concretes with 50 % of fly ash substitution did not reach the values of compressive strength of the reference concrete at any age.

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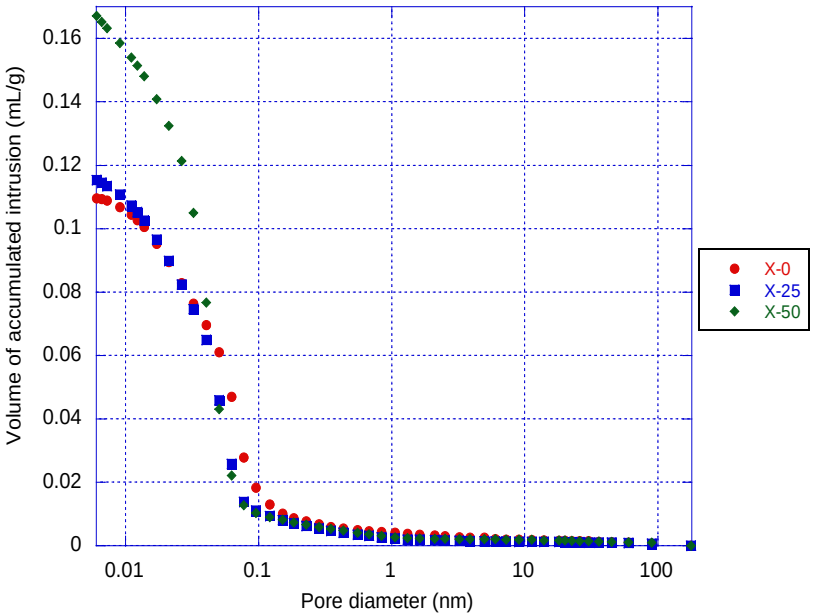
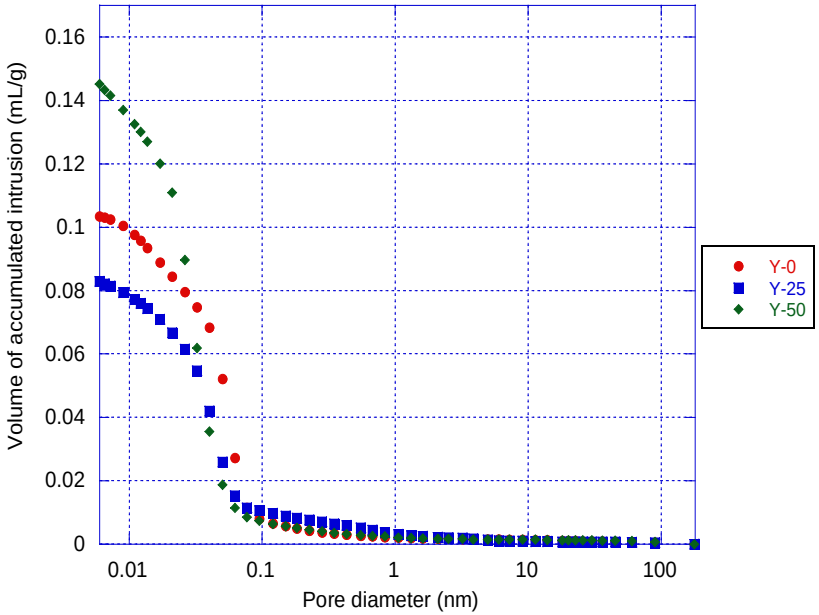
Results (1)

Mercury intrusion porosimetry

Concretes: *X*



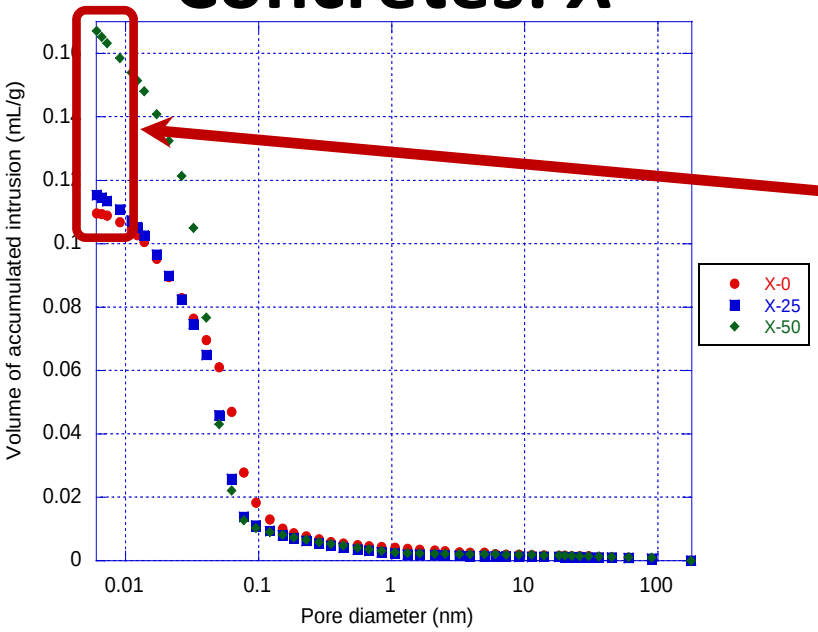
Concretes: *Y*



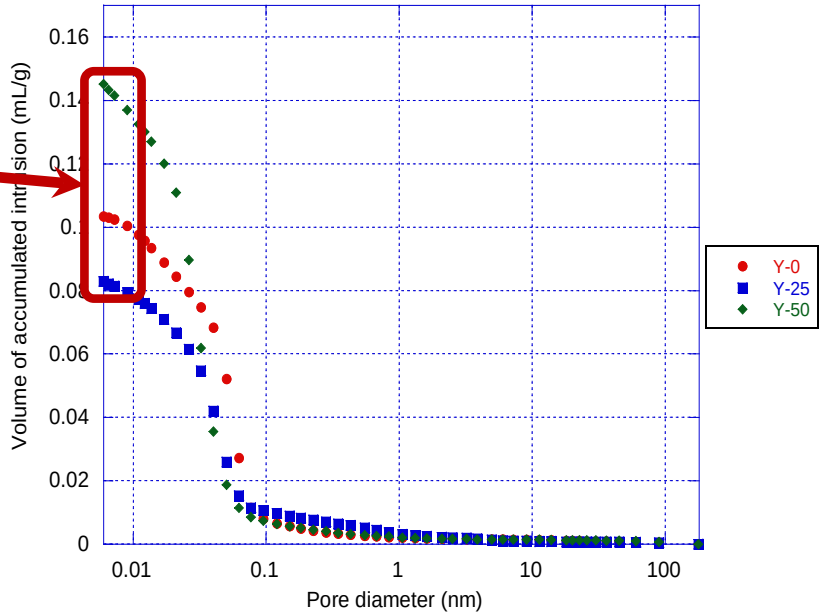
Results (1)

Mercury intrusion porosimetry

Concretes: *X*



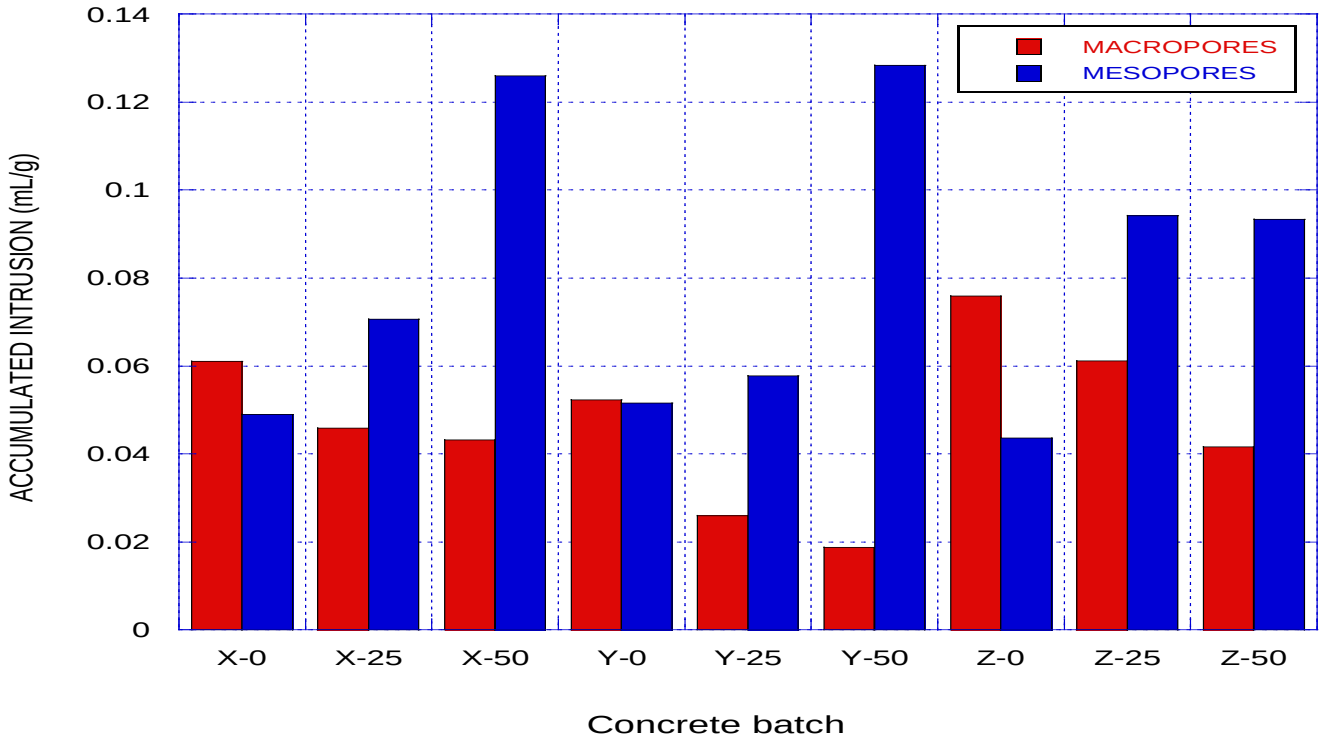
Concretes: *Y*



The lowest mercury intrusion volumes were obtained with concretes mixed with cement *Y*

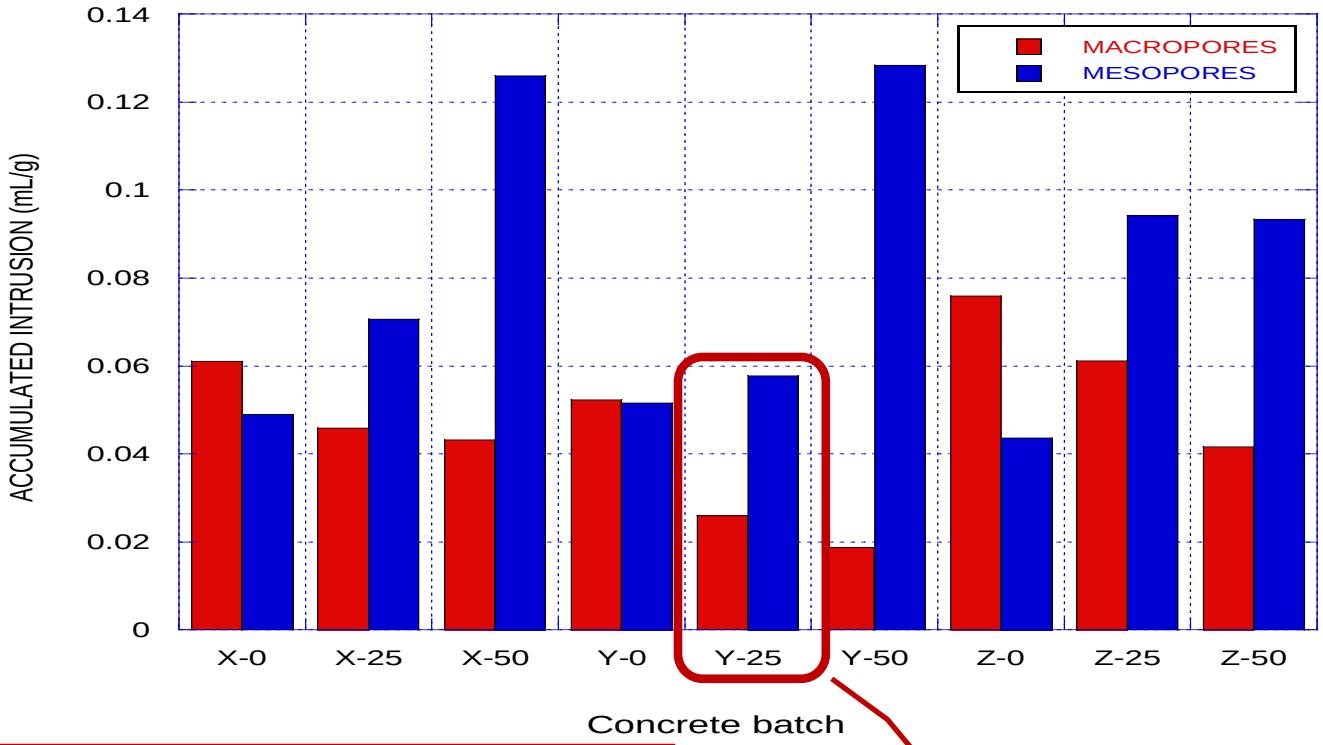
Results (2)

Pore distribution



Results (2)

Pore distribution



The best result obtained was the experimental concrete with 25% of fly ash substitution of cement *Y*

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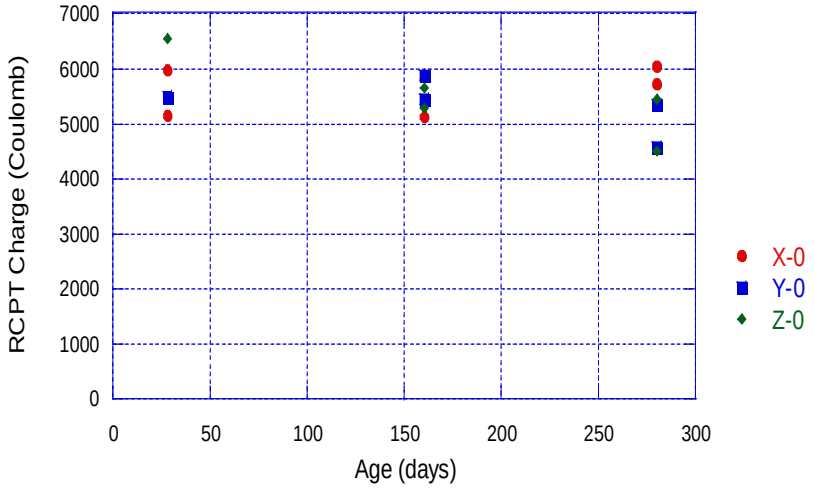
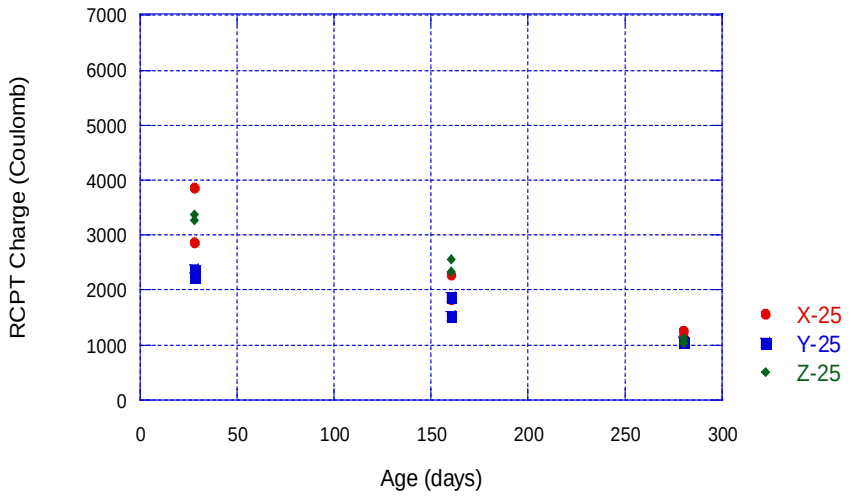
Results (1)

Rapid Chloride-ion Permeability Test (RCPT)

Concretes: 0% FA



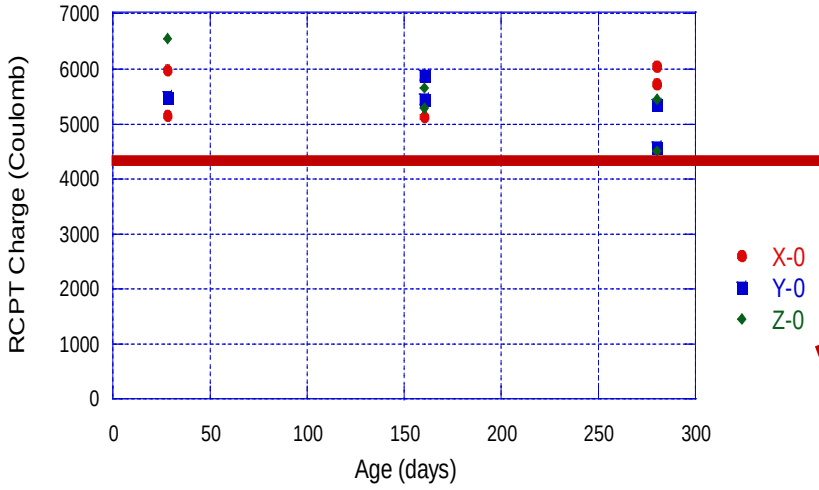
Concretes: 25% FA



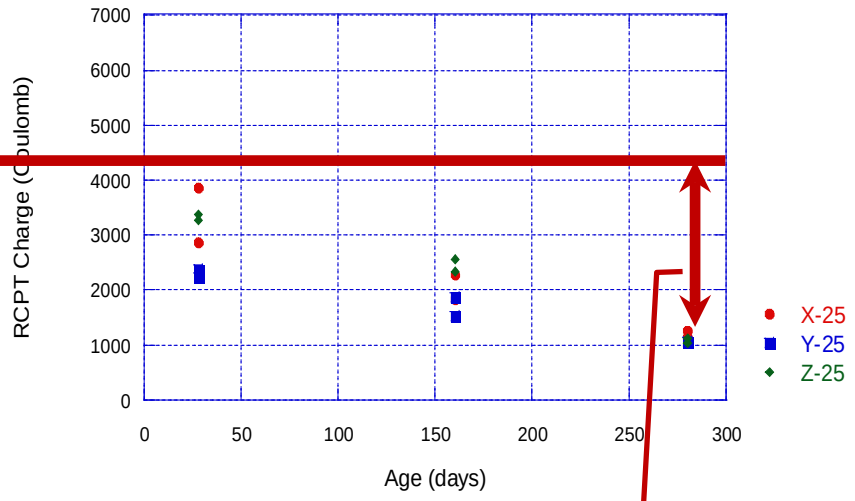
Results (1)

Rapid Chloride-ion Permeability Test (RCPT)

Concretes: 0% FA



Concretes: 25% FA



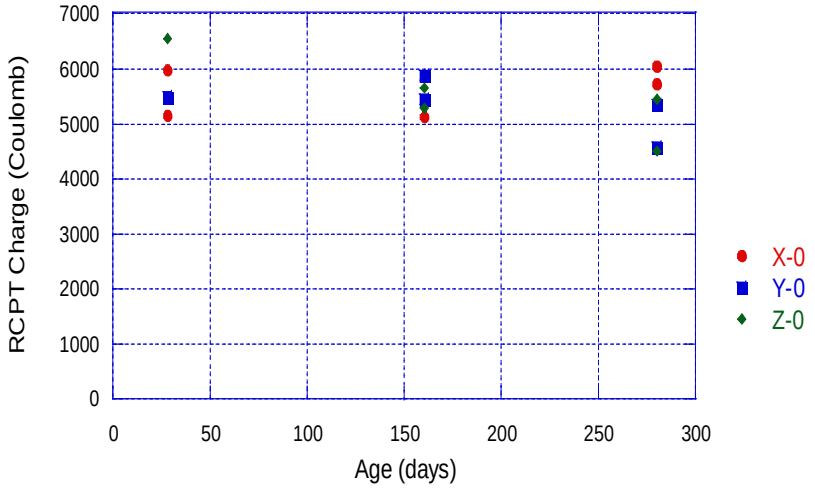
Experimental concretes (with fly ash) have higher resistance to chloride ion permeability, especially during a long-term period.

Reference concretes show high permeability at all ages.

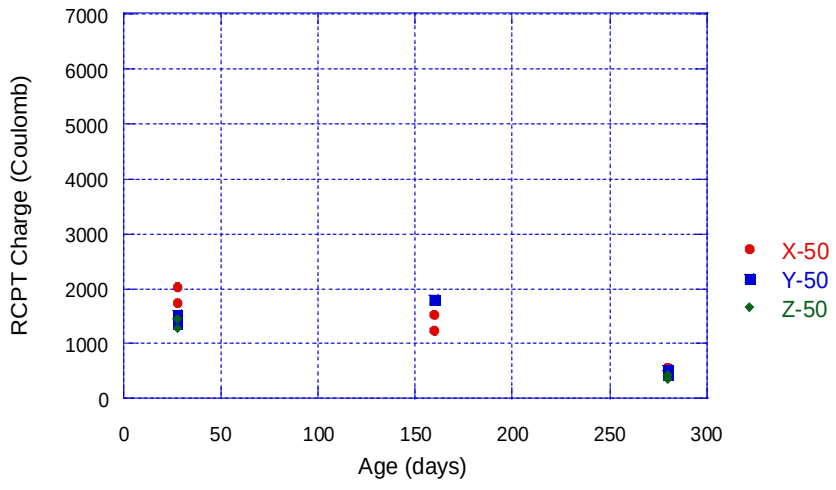
Results (2)

Rapid Chloride-ion Permeability Test (RCPT)

Concretes: 0% FA



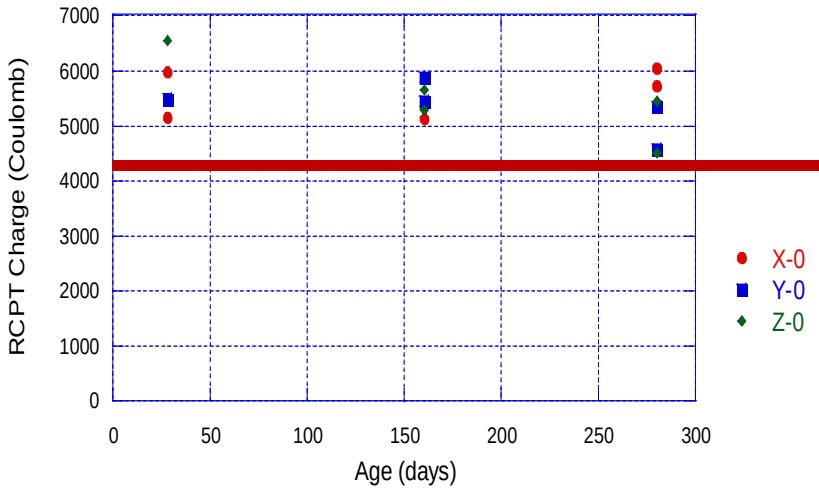
Concretes: 50% FA



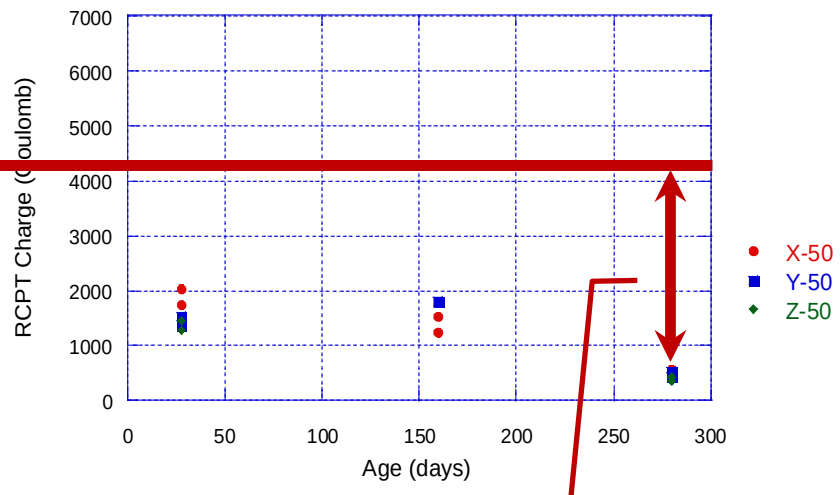
Results (2)

Rapid Chloride-ion Permeability Test (RCPT)

Concretes: 0% FA



Concretes: 50% FA



Mixtures with 50 % of fly ash substitution improved their resistance to chloride ion permeability in all cases

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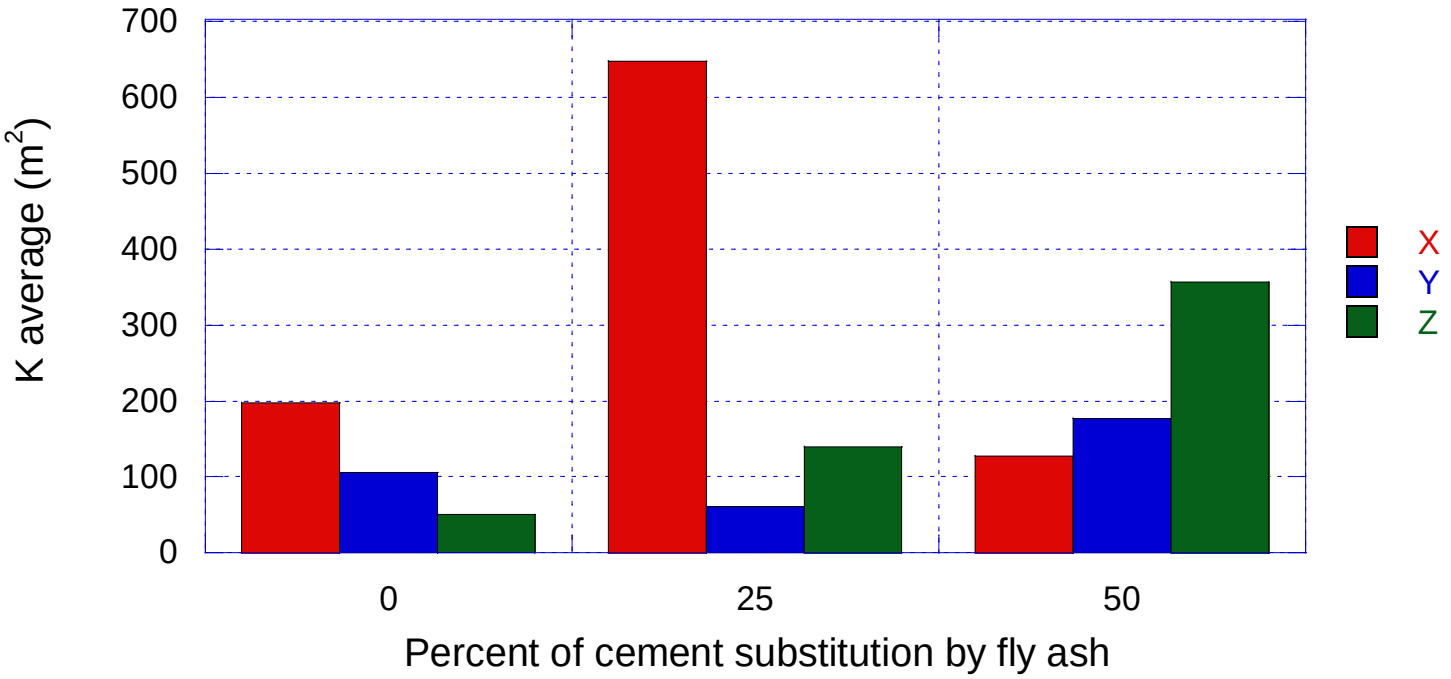
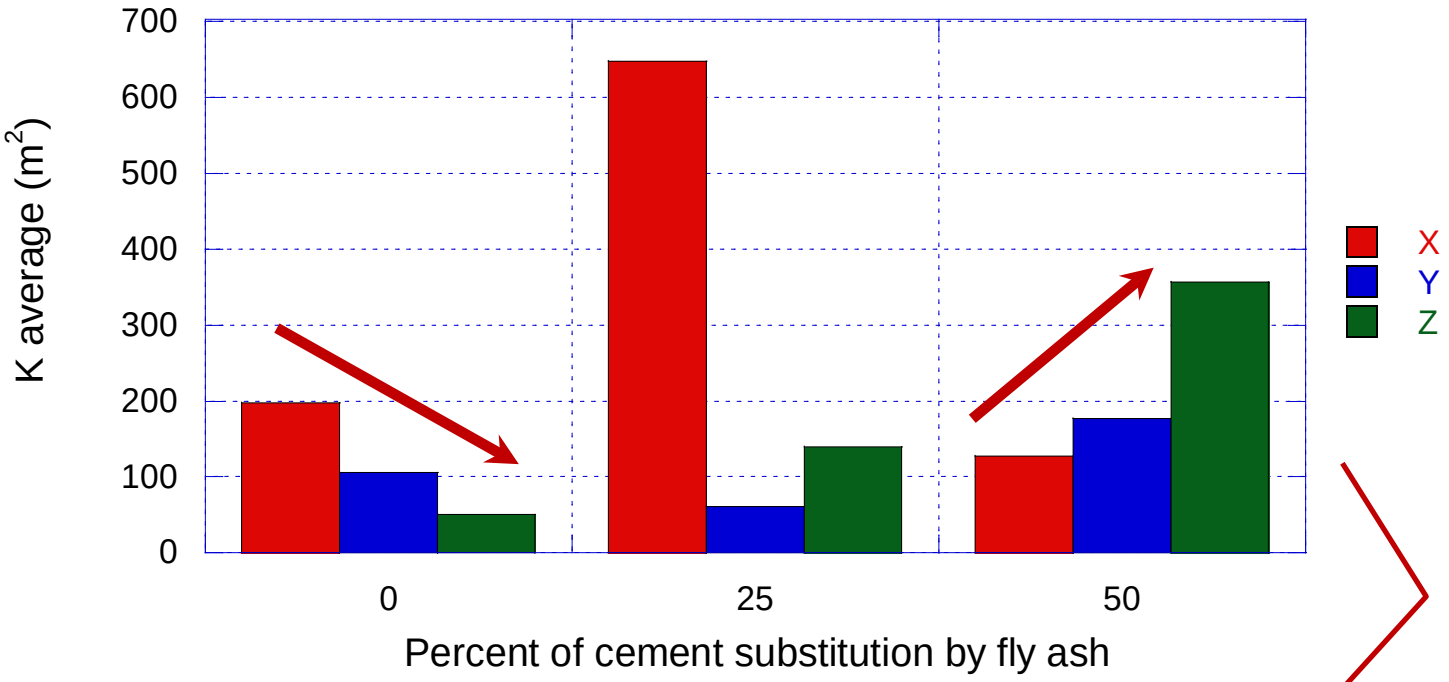
Results (1)

Air permeability



Results (1)

Air permeability



Concretes variations were observed depending on the type of cement used for the mixture, and the behavior of the results does not coincide with other tests carried out.

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Conclusions

- This study proves that the performance of concrete with fly ash varies based on the characteristics of the cement used and the amount of fly ash used in the mixture.
- The best result for experimental concrete with 25% of fly ash substitution were obtained with concrete *Y* (C_3S = 55.31%).
- The best result for experimental concrete with 50% of fly ash substitution were obtained with concrete *Z* (*C_3S = 77.04%).*

Conclusions

- The reference concretes have high permeability to chloride ions at any age.
- The results show that even when all the cements used comply with type I classification according to ASTM C 150, there is a tendency to performance variation of the concretes mixed with cement with different mineralogical composition.

Acknowledgements

The authors express their acknowledgments to the professors Amparo Moragues Terrades, Antonio A. González Quevedo and Felipe J. Acosta Costa for their advice in the development of this research. To the Essroc San Juan personnel, Eng. Francisco Bravo, Juan M. Rivera, and Eng. Rubén Segarra for their help and attention during the process of testing in their laboratories. Thanks to Monserrate Ortiz and María Aránzazu Hueso for their effort in this project and for their teaching on laboratory equipment management for the University of Puerto Rico – Mayagüez Campus and Universidad Politécnica de Madrid respectively.

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