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# Multiphysical characterization of lime treated sand-bentonite mixtures

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- Introduction
- Context of the study
- Multi-physical Characterization
- Interpretation
- Conclusions

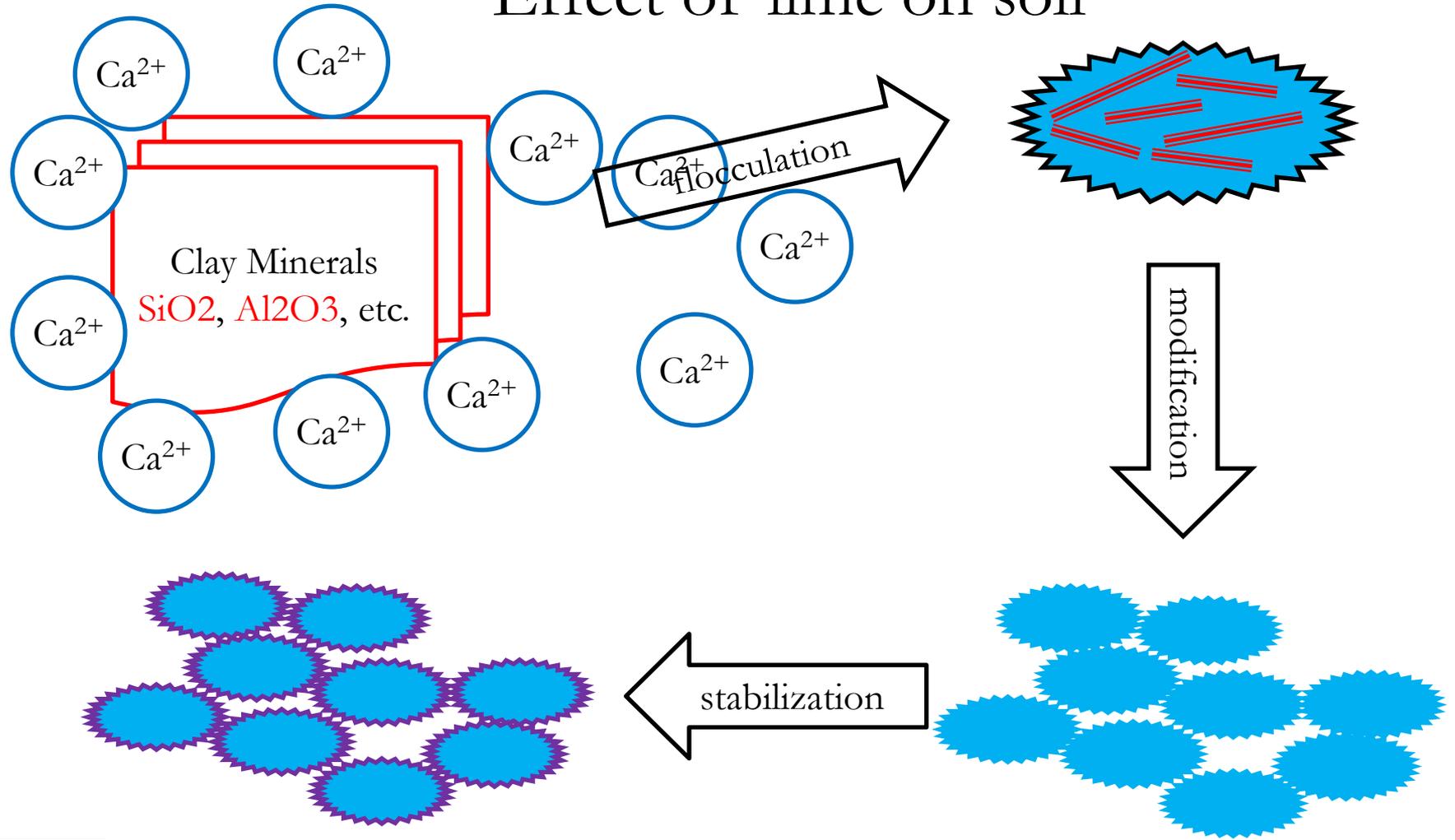
# Introduction

## Lime treatment of soils



# Introduction

## Effect of lime on soil



many weeks: pouzz. reaction

instantaneous

# Introduction



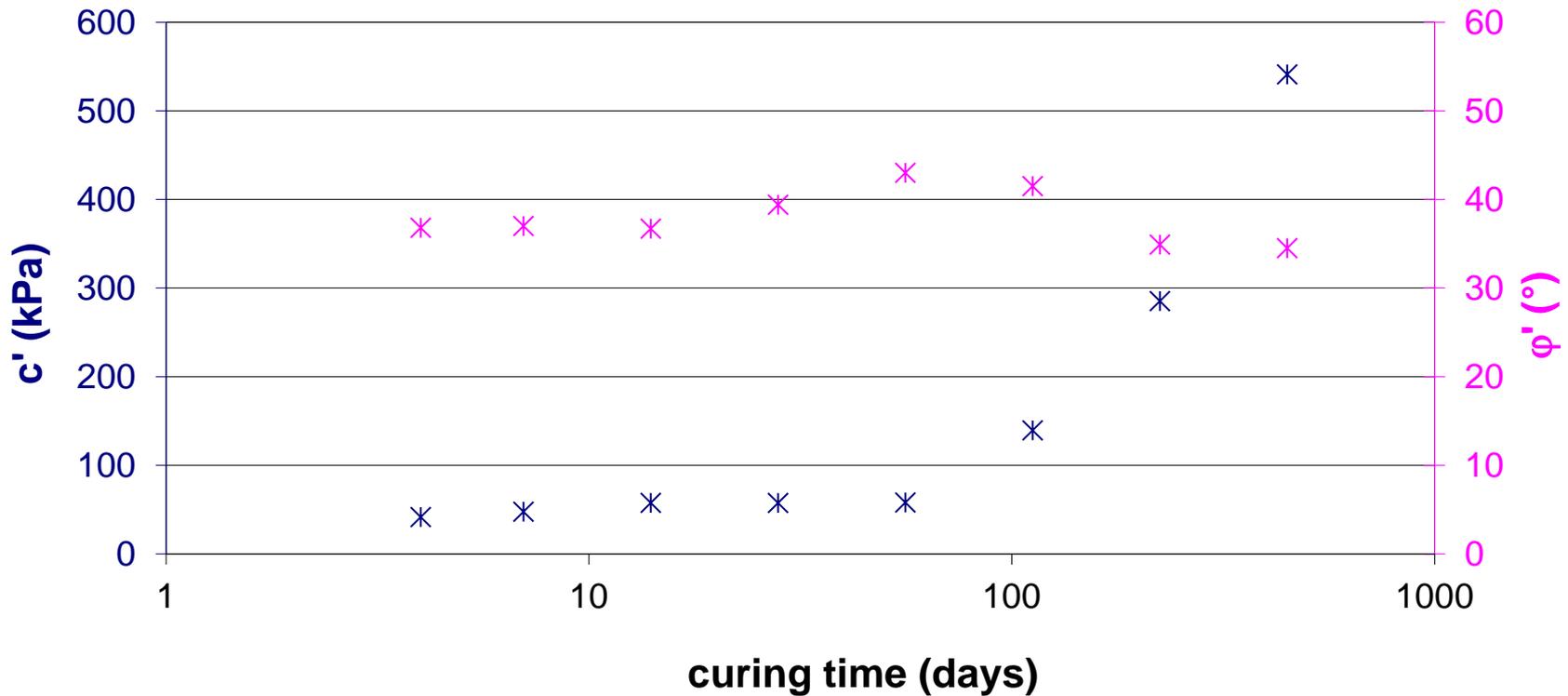
## Previous researches

- Study of stabilisation evolution through curing time
- Different studied soils : important database (De Bel 2007, Bollens 2005)  
More than 5 different silty soils
- Characterization of evolving mechanical and chemical properties

# Introduction

## Previous researches

**MLD**  
**Evolution of  $c'$  and  $\phi'$  with curing time at 20°C**



# Introduction



## Previous researches

- Studied soils are different from each other
- Different grain sizes
- Different clay mineral compositions
- Interfering materials : organic matter, gypsum, iron minerals, ...
- Different non-clay matter

**Hard to predict stabilisation evolution**

# Introduction

## Proposition



- Synthetic soil with controlled composition
- Controlled grain size
- Use of one clay mineral
- Removal of all interfering matter
- One type of skeleton (one grain size)

**Stabilization in function of synthetic mixture → better comprehension**

# Context of the study

## Alternative : Synthetic soil



- Sand-Clay mixture
- Sand part : constitutes the skeleton
  - No reaction with lime
  - Bridges for lime-clay aggregates
- Clay part : constitutes the matrix
  - Highly reactive with lime
  - Ensures the material's cohesion

# Context of the study

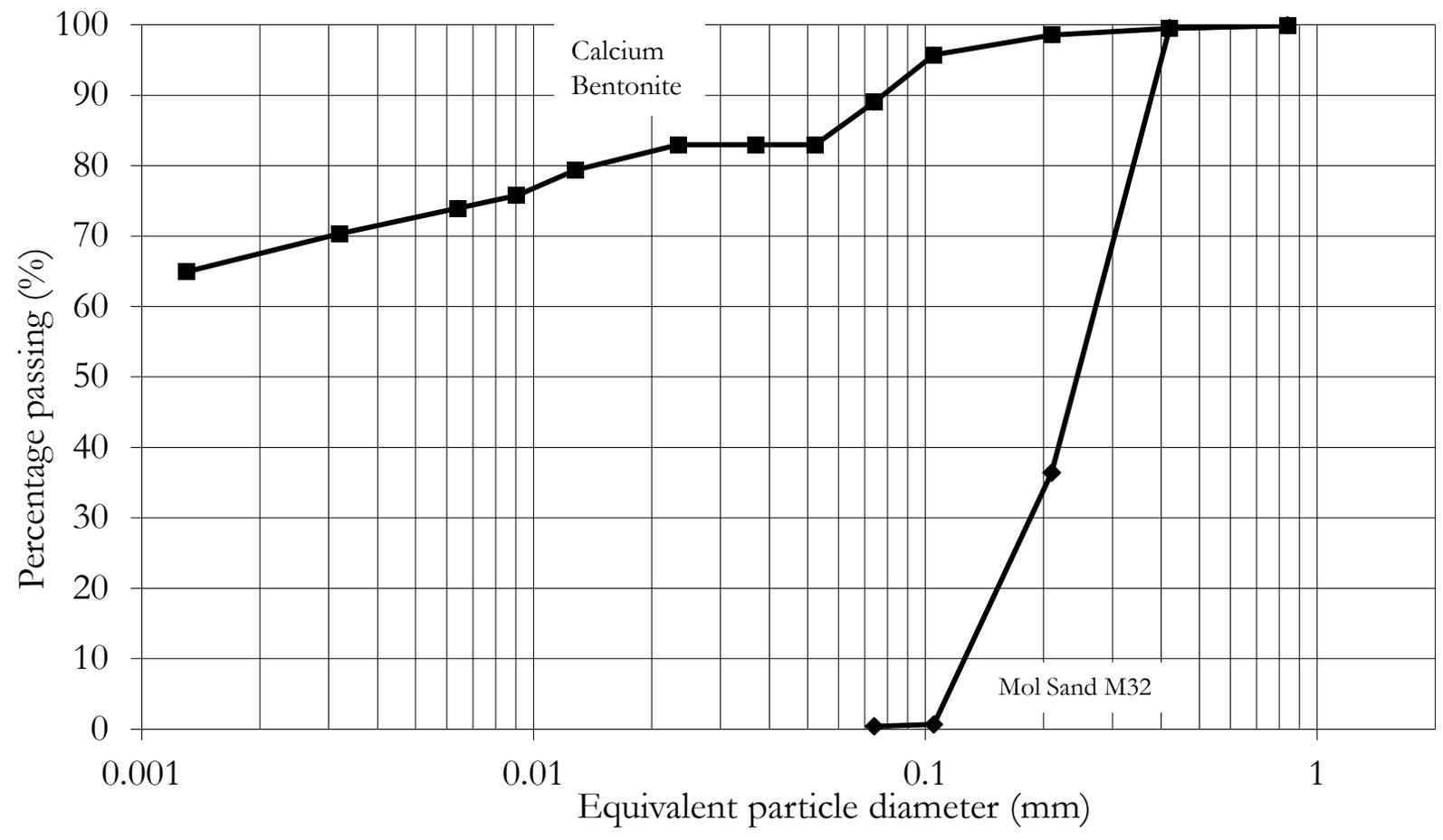
## Alternative : Synthetic soil



- Sand part : Mol Sand M32
  - Homometric
  - Grain size around 250 $\mu$ m
  
- Clay part : Calcium Bentonite
  - One clay mineral : montmorillonite (high react.)
  - No (or small) swelling factor ( $\neq$  Sodium Bent.)

# Context of the study

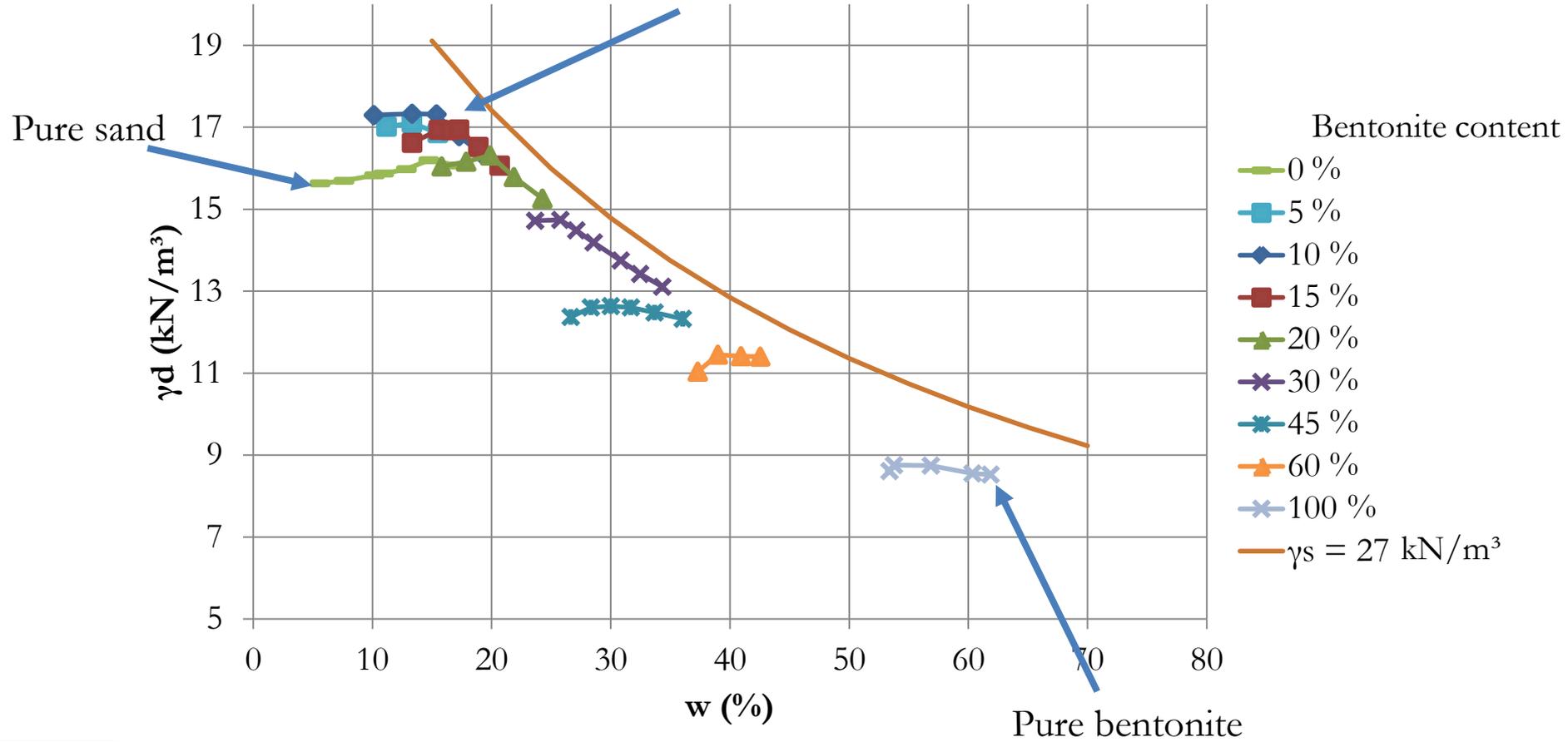
## Grain size distributions



# Context of the study

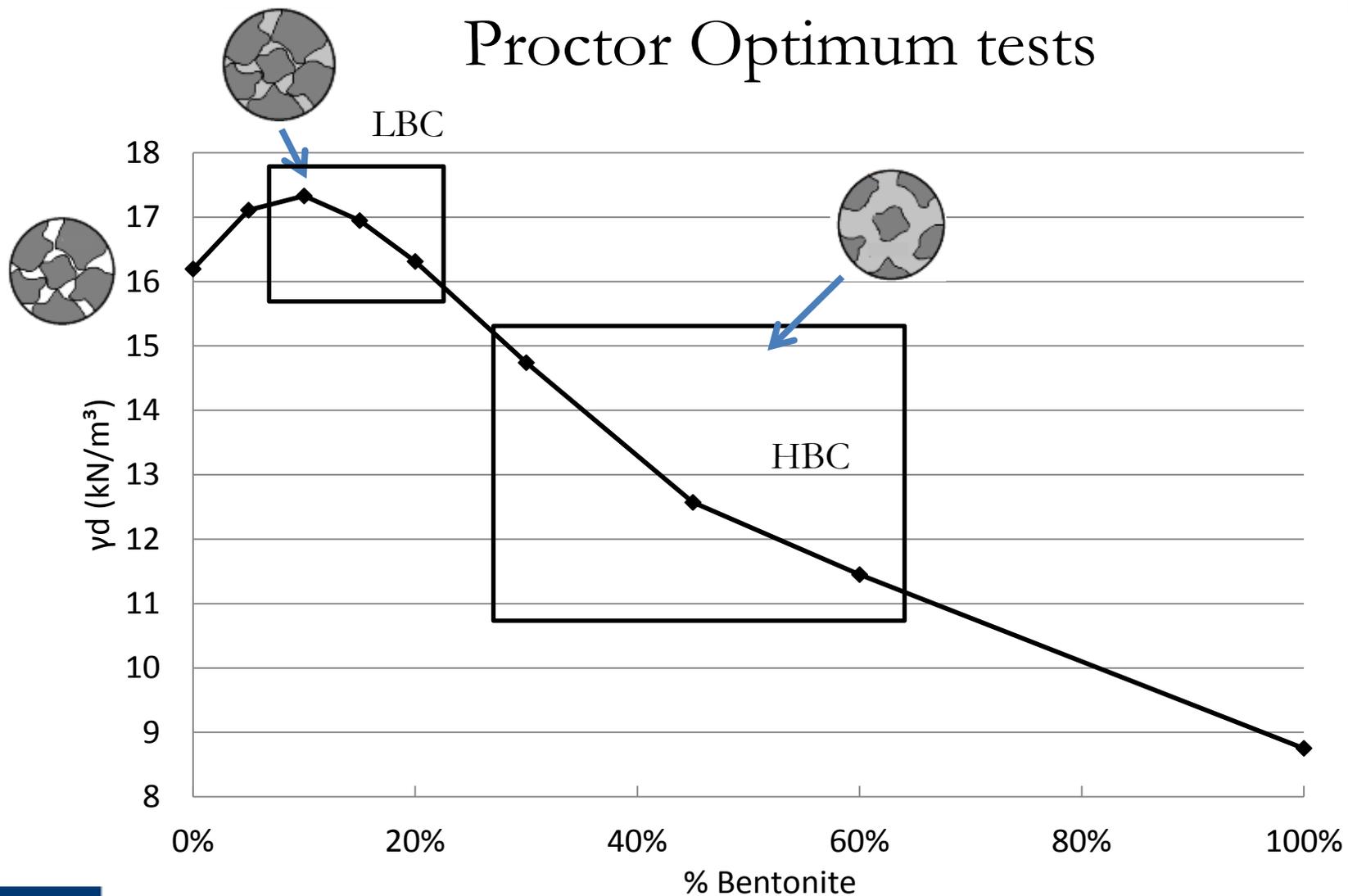
## Proctor Optimum tests

10% Bentonite – 90% Sand



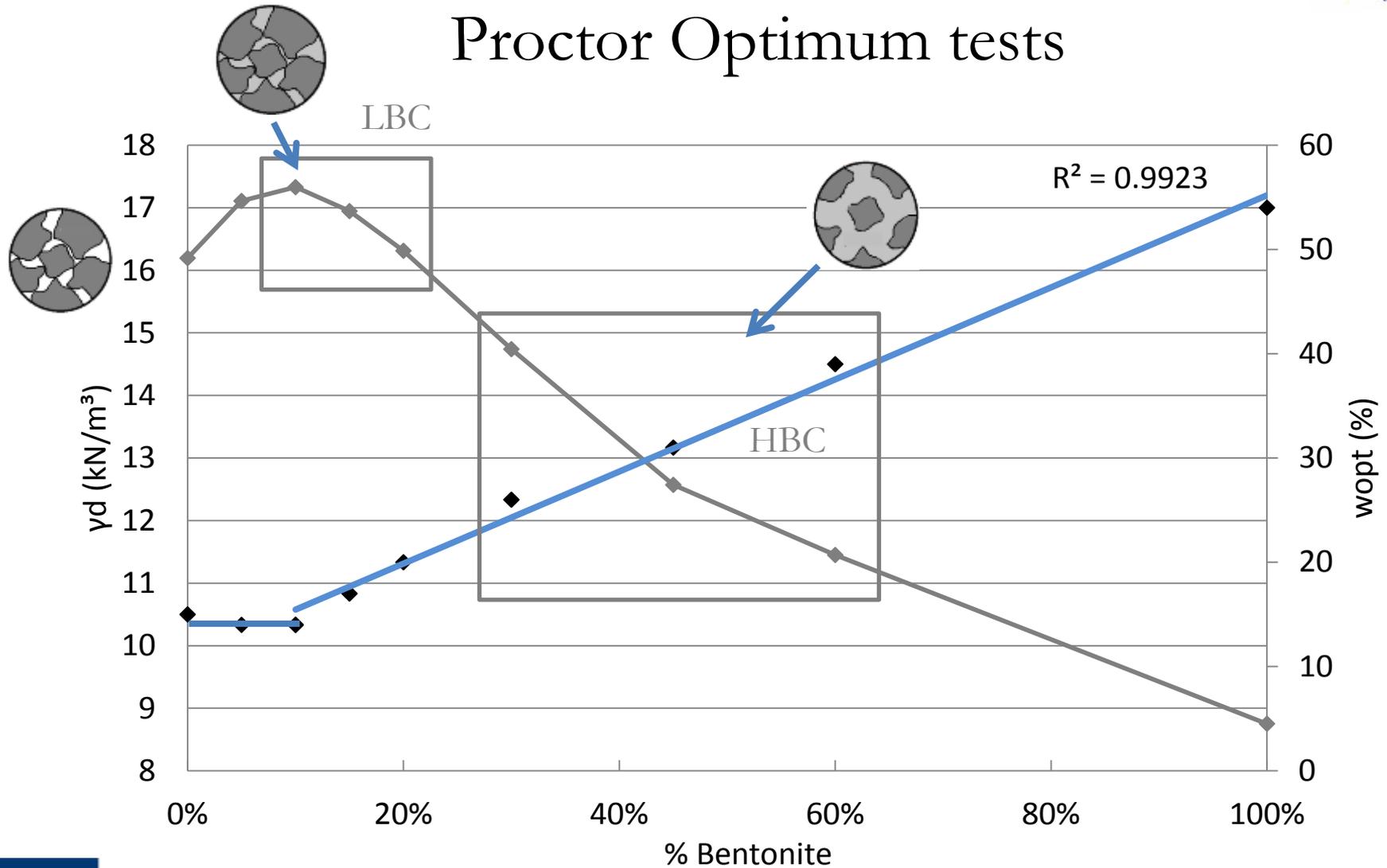
# Context of the study

## Proctor Optimum tests



# Context of the study

## Proctor Optimum tests



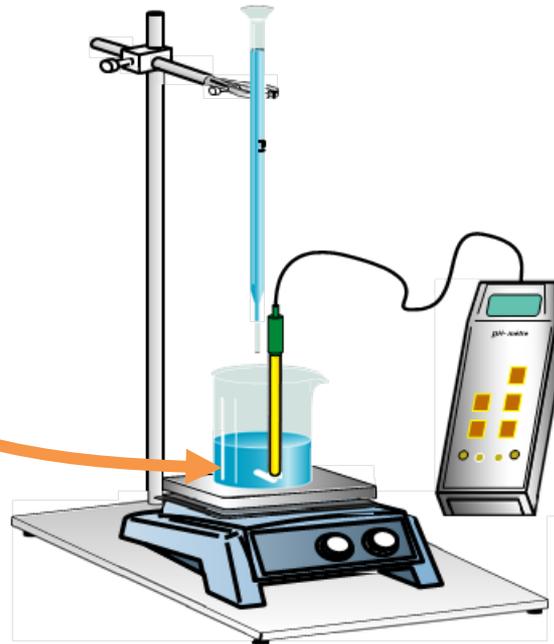
# Context of the study

## Multi-physical Characterization

Unconfined  
Compression Test



Lime Consumption



Electrical Resistivity



Leduc experiment  
NBN B13-202, 1997

# Context of the study

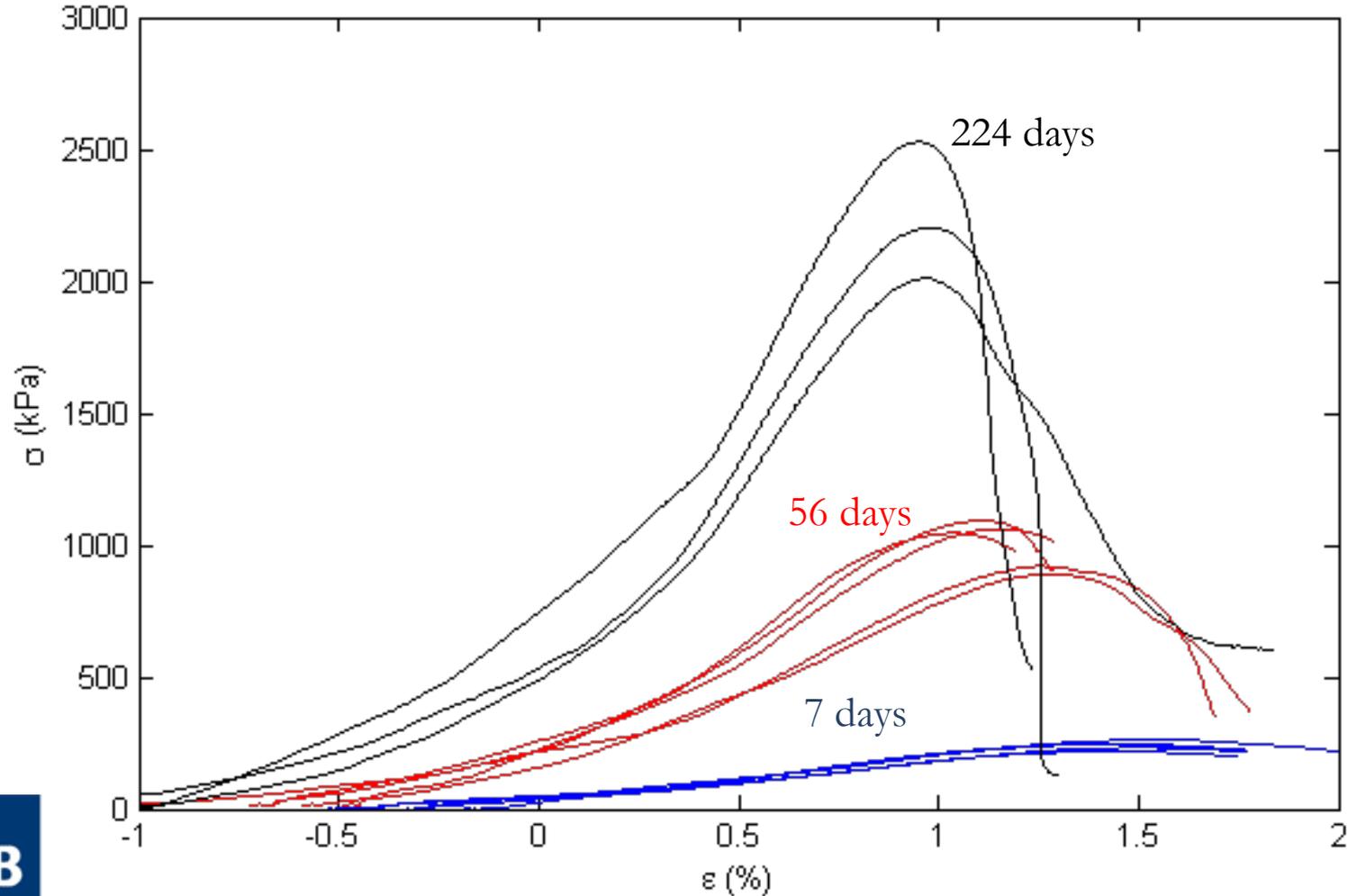


## Mixtures Investigated

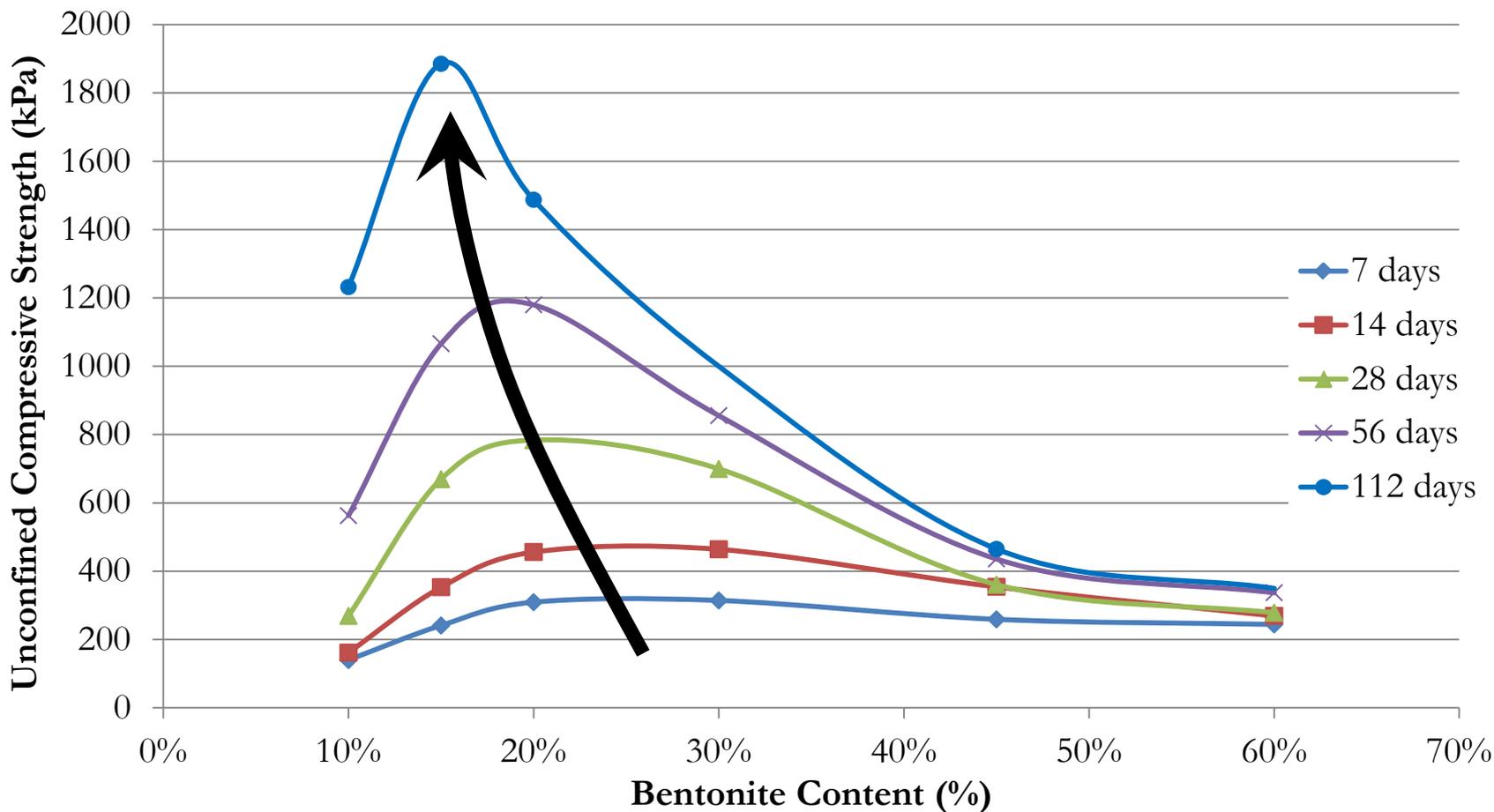
	Low Bentonite Content (LBC)	High Bentonite Content (HBC)						
+1% Lime	<table border="1"> <tr> <td>10% B 90% S</td> <td>15% B 85% S</td> <td>20% B 80% S</td> </tr> </table> <p>Unconfined Compressive Strength Lime Consumption Electrical Resistivity</p>	10% B 90% S	15% B 85% S	20% B 80% S	<p>1% Lime to low for HBC</p>			
10% B 90% S	15% B 85% S	20% B 80% S						
+2% Lime	<table border="1"> <tr> <td>10% B 90% S</td> <td>15% B 85% S</td> <td>20% B 80% S</td> </tr> </table> <p>Unconfined Compressive Strength Lime Consumption Electrical Resistivity</p>	10% B 90% S	15% B 85% S	20% B 80% S	<table border="1"> <tr> <td>30% B 70% S</td> <td>45% B 55% S</td> <td>60% B 40% S</td> </tr> </table> <p>Unconfined Compressive Strength Lime Consumption</p>	30% B 70% S	45% B 55% S	60% B 40% S
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## Unconfined Compression Strength (2% lime)

Example from the 15% Bentonite - 85% Sand



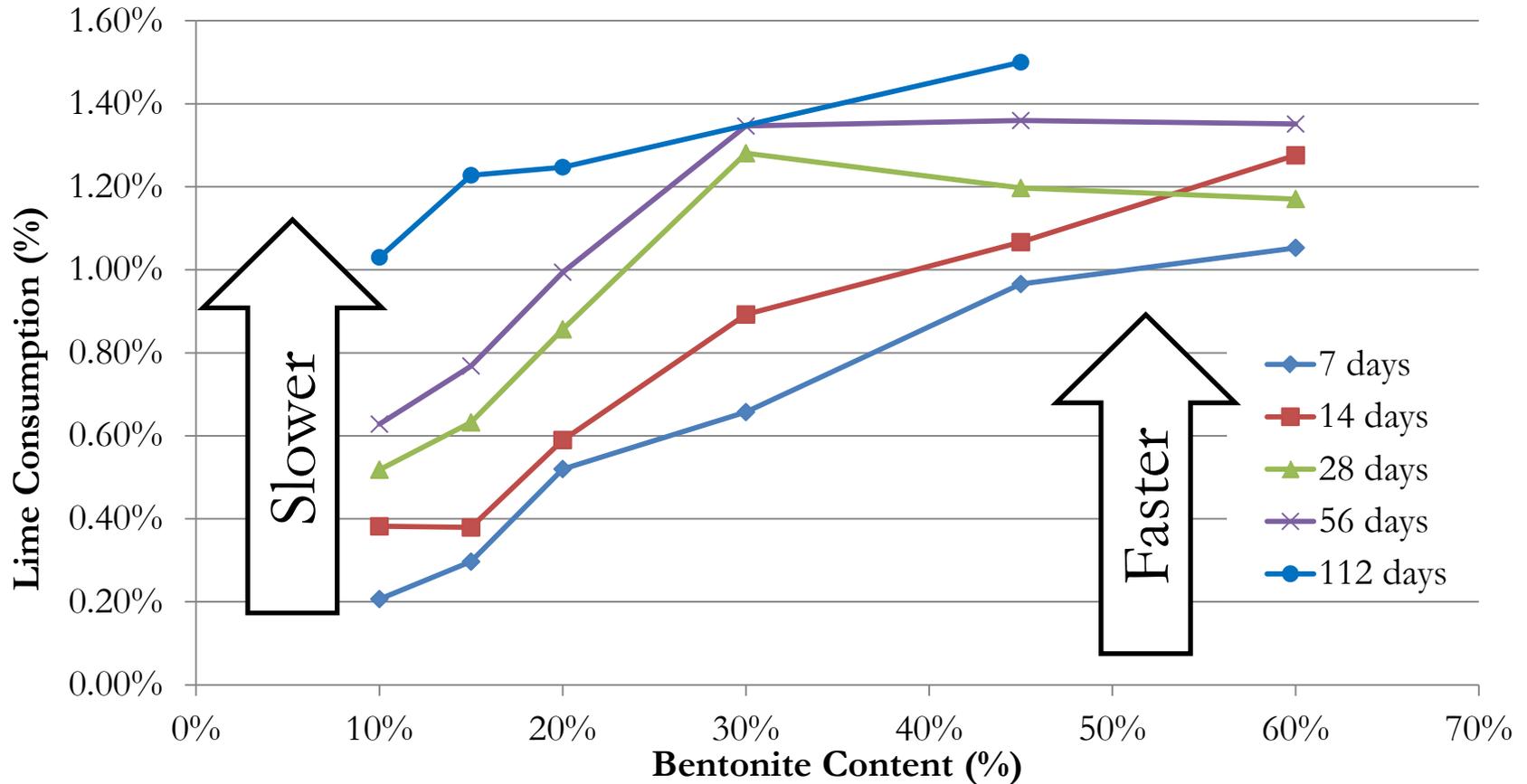
## Unconfined Compression Strength (2% lime)



UCS of the mixtures all treated with 2% lime from 7 to 112 days  
 Maxima change and tend to lower bentonite contents

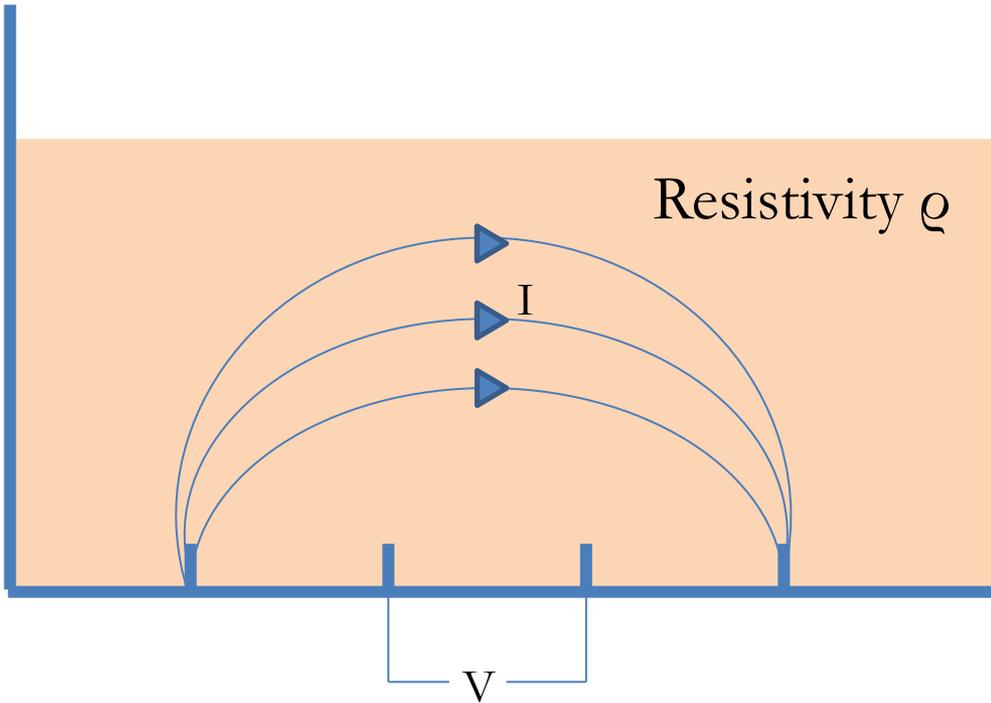
# Results

## Lime Consumption (2% lime)



LC of the mixtures all treated with 2% lime from 7 to 112 days  
 Higher bentonite contents consume quicker than lower b.c

## Electrical resistivity



Resistance  $R = V/I$

Resistivity  $\rho = R \cdot k$

$k$  characteristic length factor of the container geometry

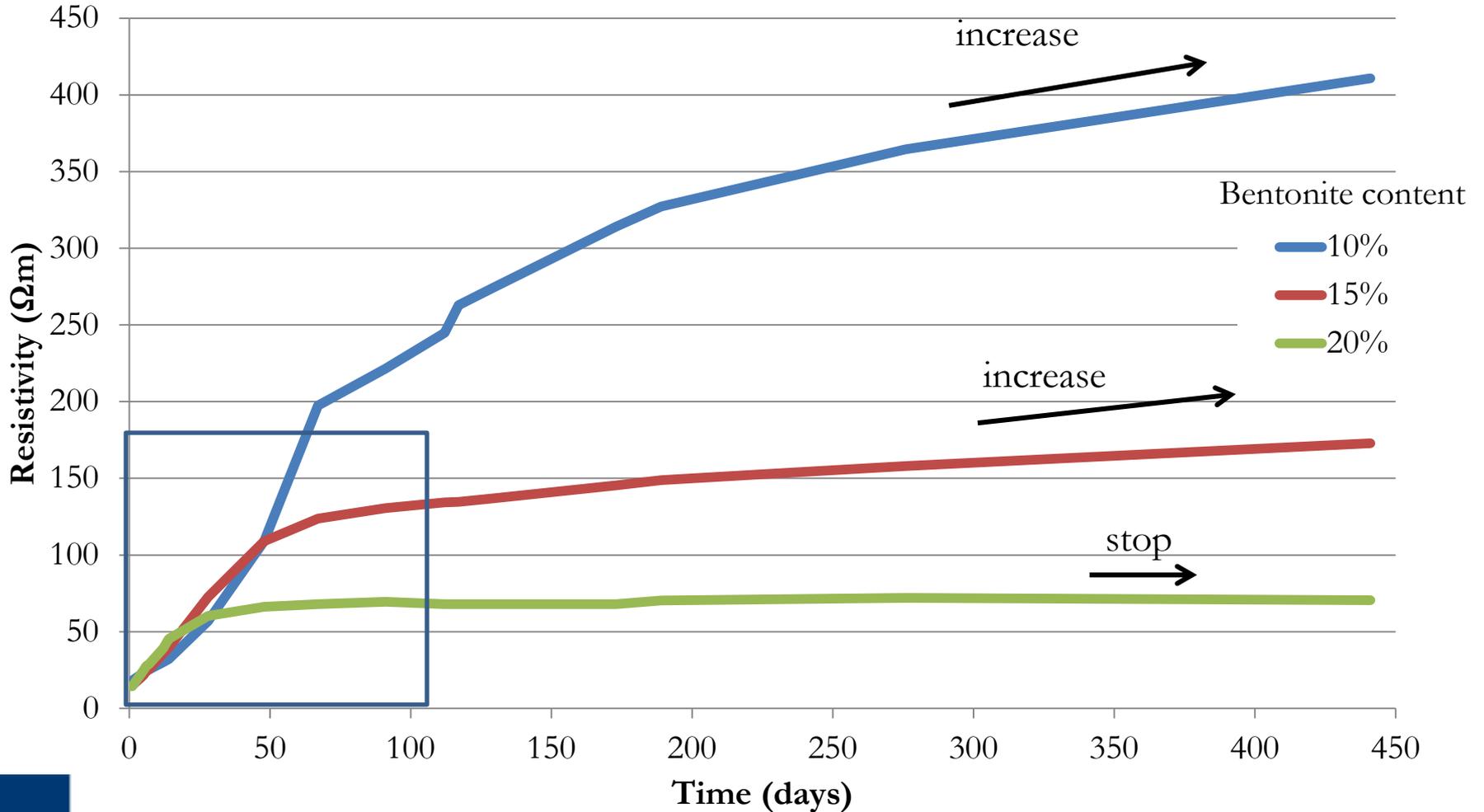
$k$  calibrated with precise saline solution with known  $\rho$

## Electrical resistivity

- Conductivity proportional to quantity of ions in solution (here: unreacted lime)
- Gives good estimation of reaction advancement
- Non-destructive

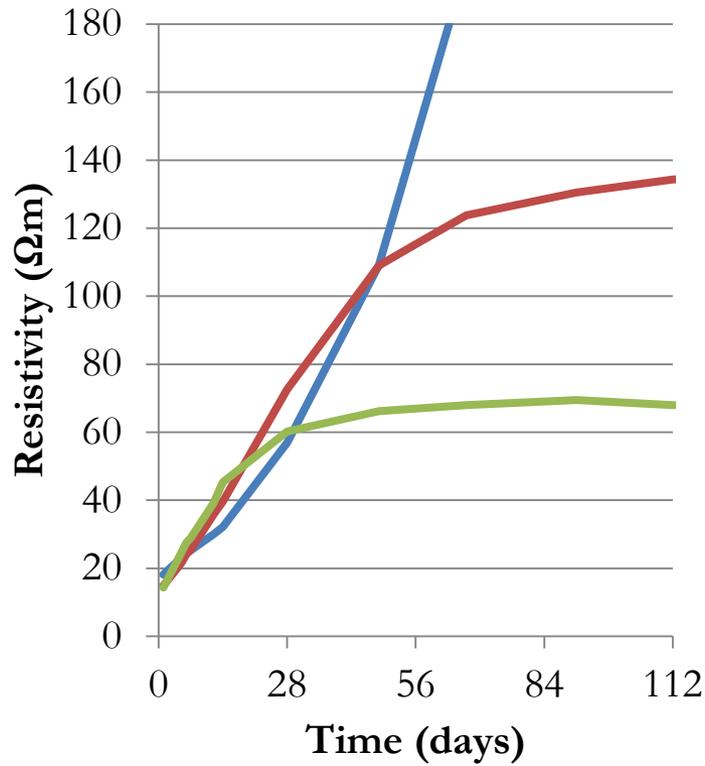


## Electrical resistivity (1% lime)

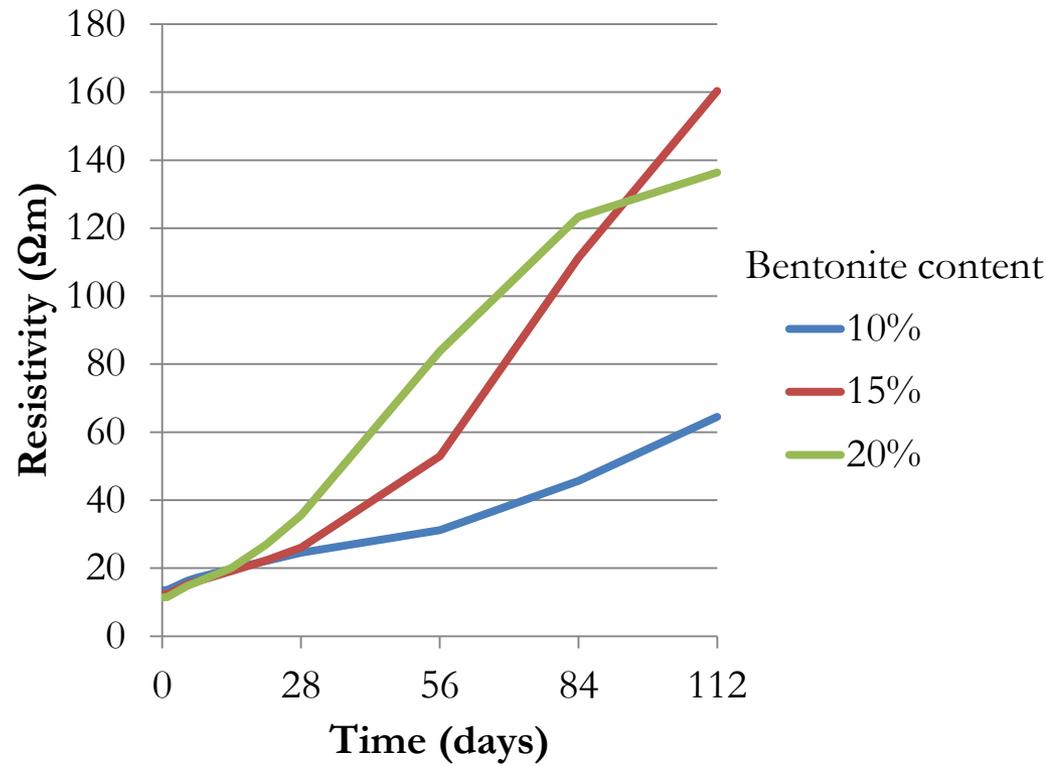


## Electrical resistivity (1% lime & 2% lime)

1% Lime

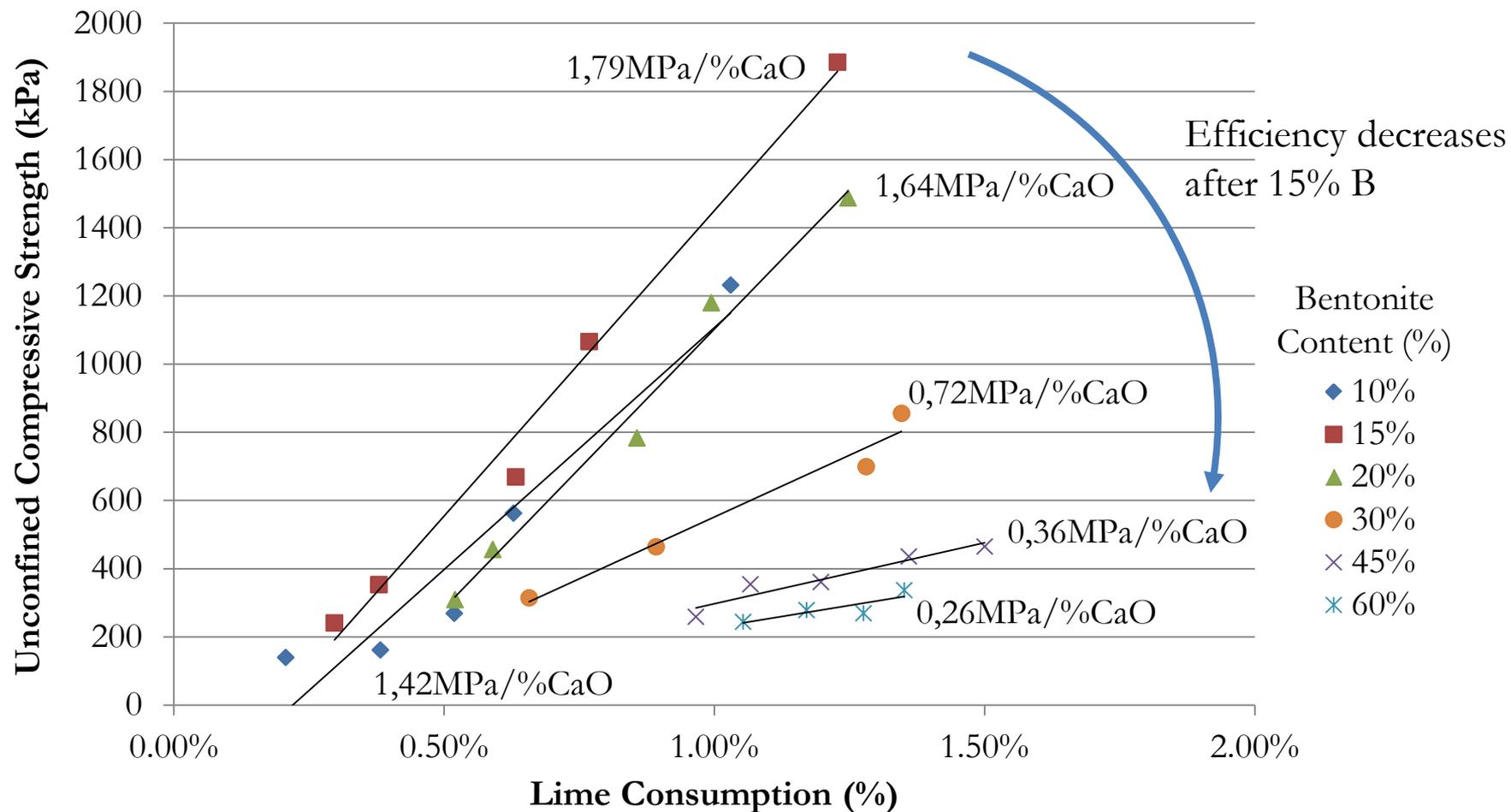


2% Lime



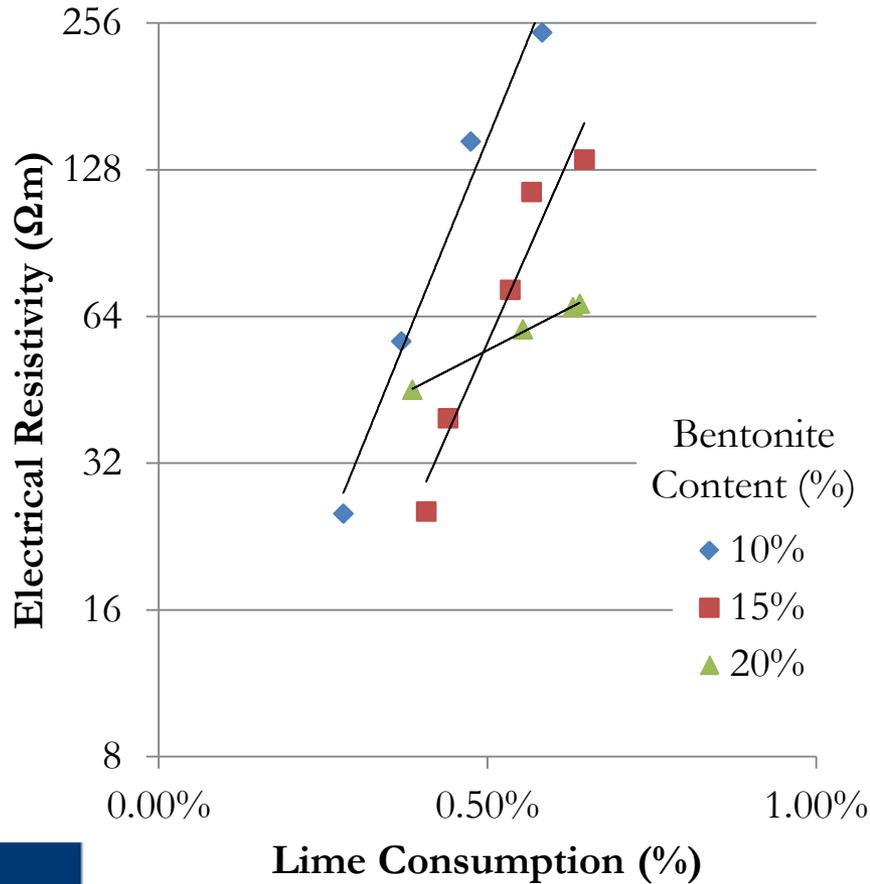
# Interpretation

## UCS vs. Lime Consumption (2% lime)

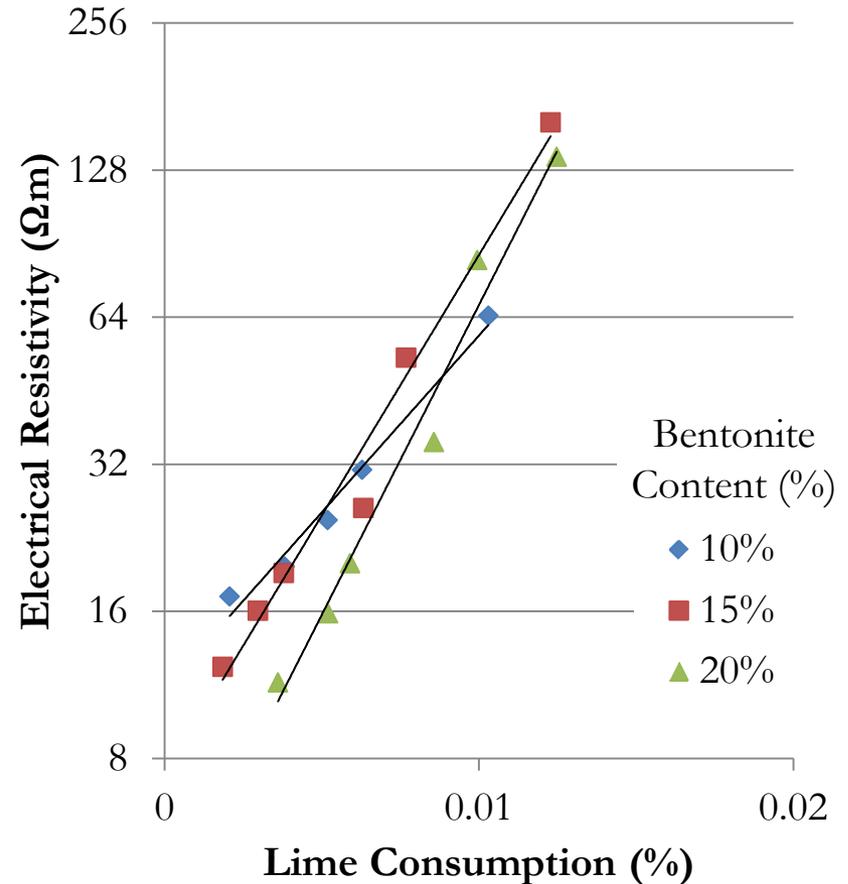


## Log(Electrical resistivity) vs. Lime Consumption

1% Lime

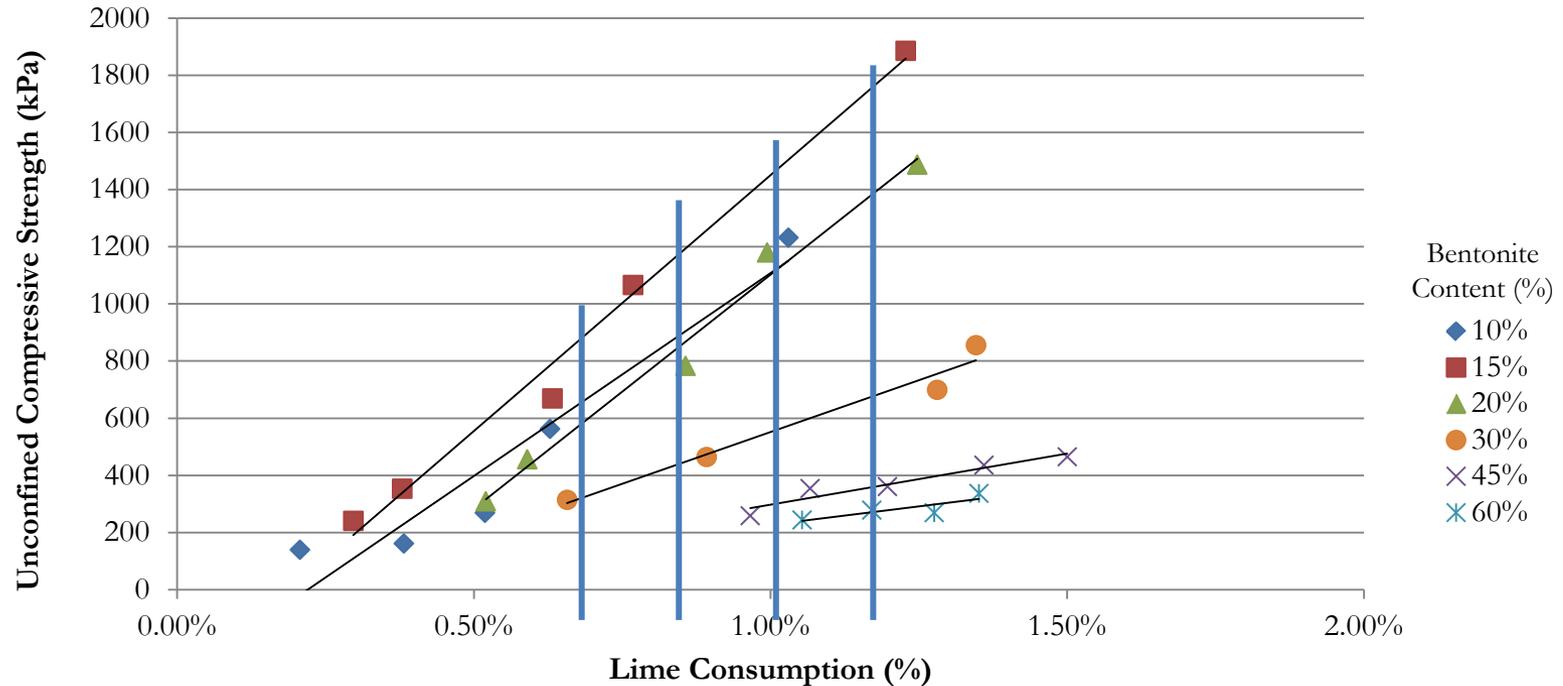


2% Lime



# Conclusion

## Conclusion UCS & LC



- For a given lime consumption : the mixture of 15% bentonite – 85% sand has the highest UCS.

# Conclusion



## Conclusion on Electrical Resistivity

- Results show the same tendency as LC graphs
- Curves begin from the same point but deviate differently for different mixtures
- From higher to lower bentonite contents:
  - The increase of resistivity is sooner
  - The decrease of speed occurs sooner
  - The final values are lower
- Tendencies are the same for both lime quantities

- All three experiments show the same behaviour
- Fastest reaction occurs with highest bentonite content
- Correlation between different experiments
- It can also be imagined to stabilize sand with lime and bentonite

Thank you  
Any questions?