CONSTRUCT

U.PORTO

FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO

Thermo-hygral-mechanical approach to self-induced stresses in concrete structures

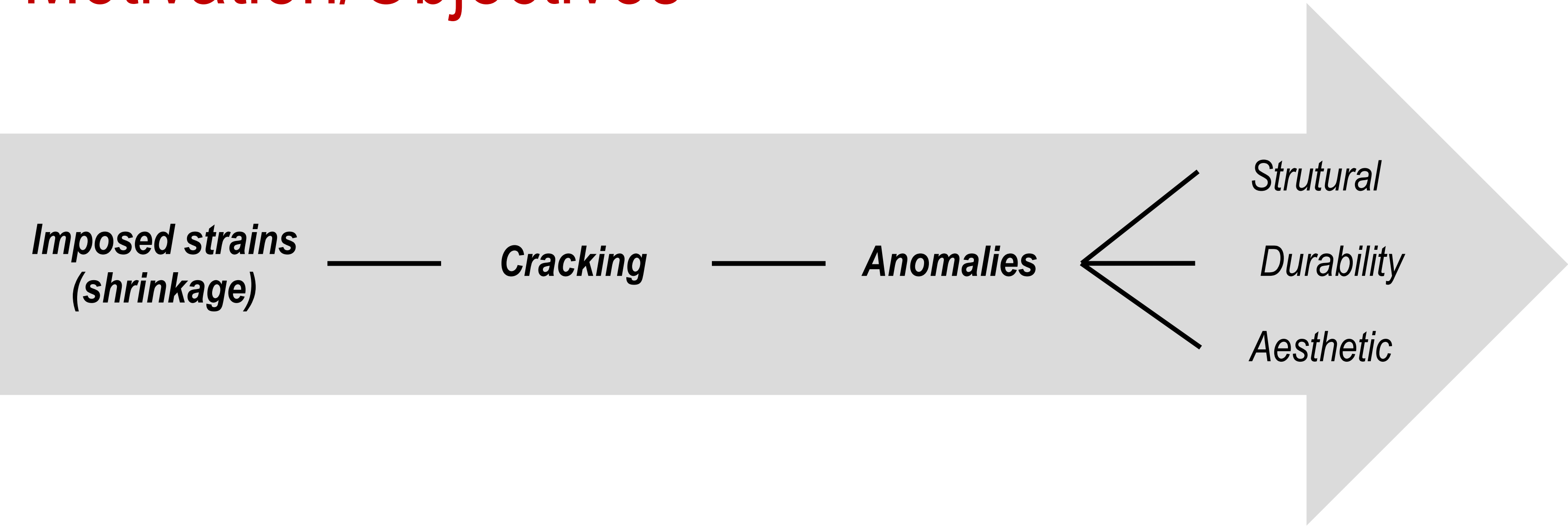
Luís Leitão

Supervisor(s) name(s):

Rui Faria (FEUP) / **Miguel Azenha** (UM)

Expected PhD conclusion year: 2016

Motivation/Objectives



Imposed strains (shrinkage)

Cracking

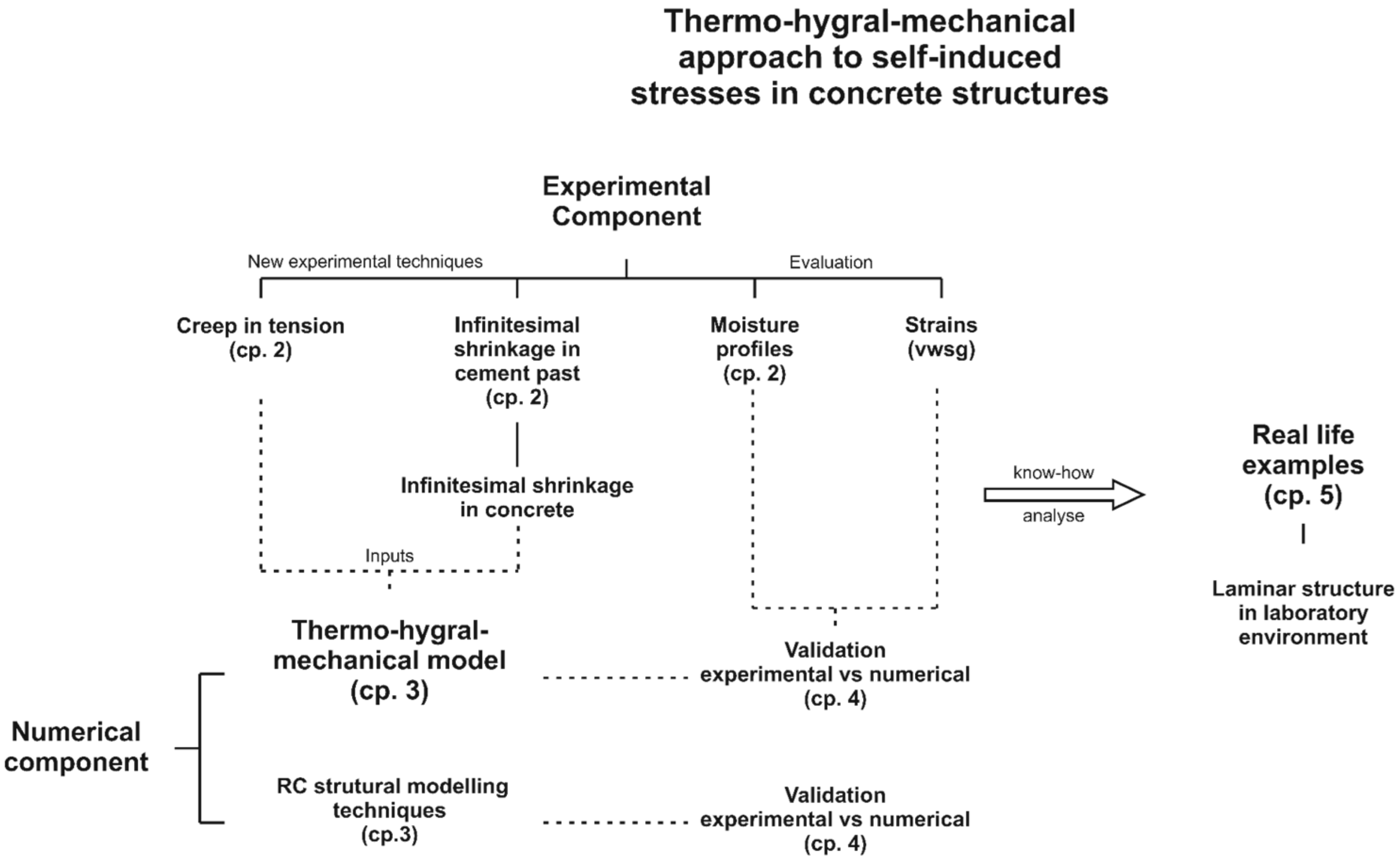
Anomalies

Strutural

Durability

Aesthetic

Motivation/Objectives



Thermo-hygral-mechanical approach to self-induced stresses in concrete structures

Experimental Component

New experimental techniques

Evaluation

Creep in tension (cp. 2)

Infinitesimal shrinkage in cement past (cp. 2)

Moisture profiles (cp. 2)

Strains (vwsg)

Infinitesimal shrinkage in concrete

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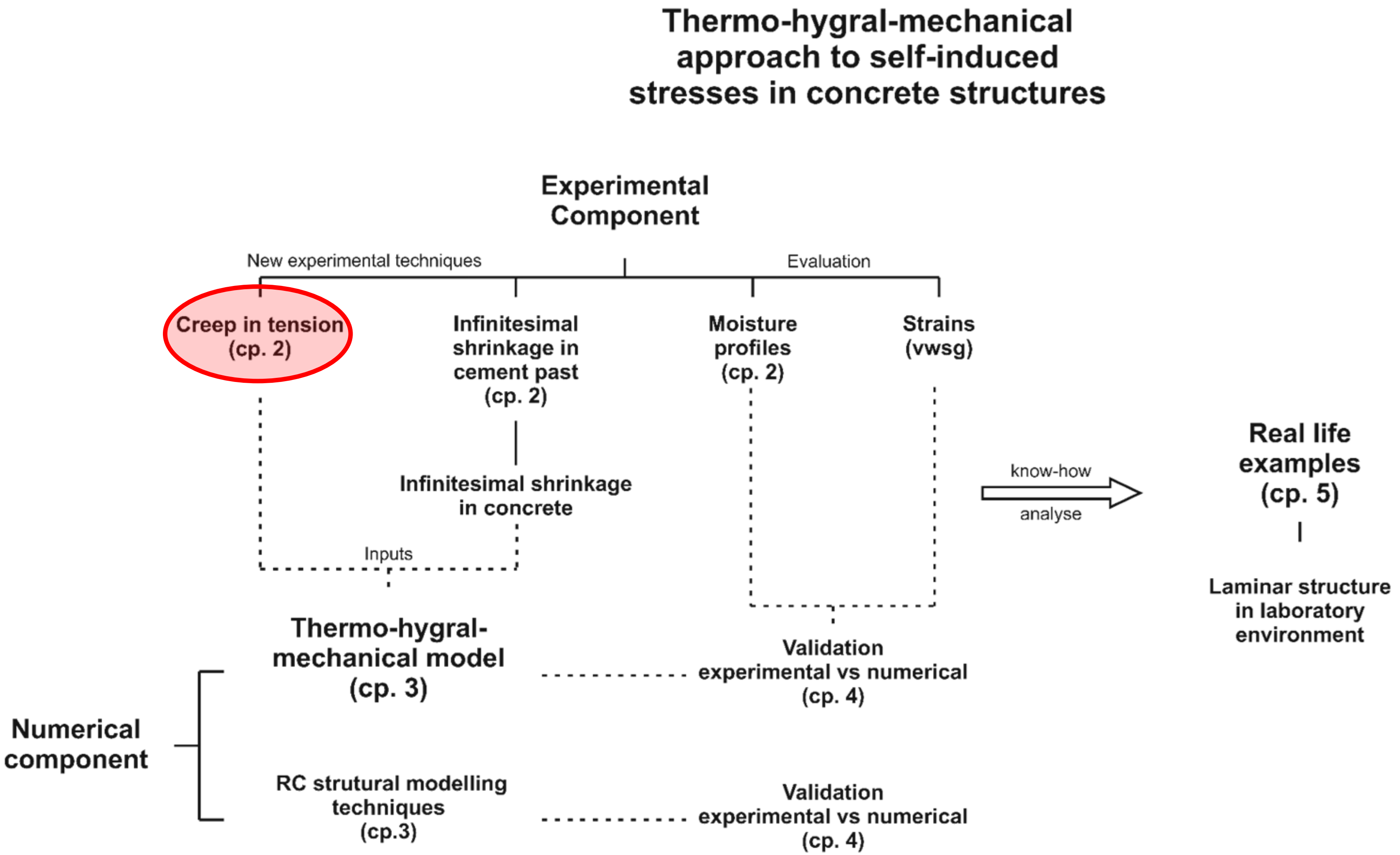
Real life examples (cp. 5)

Laminar structure in laboratory environment

Creep in tension – VRF system



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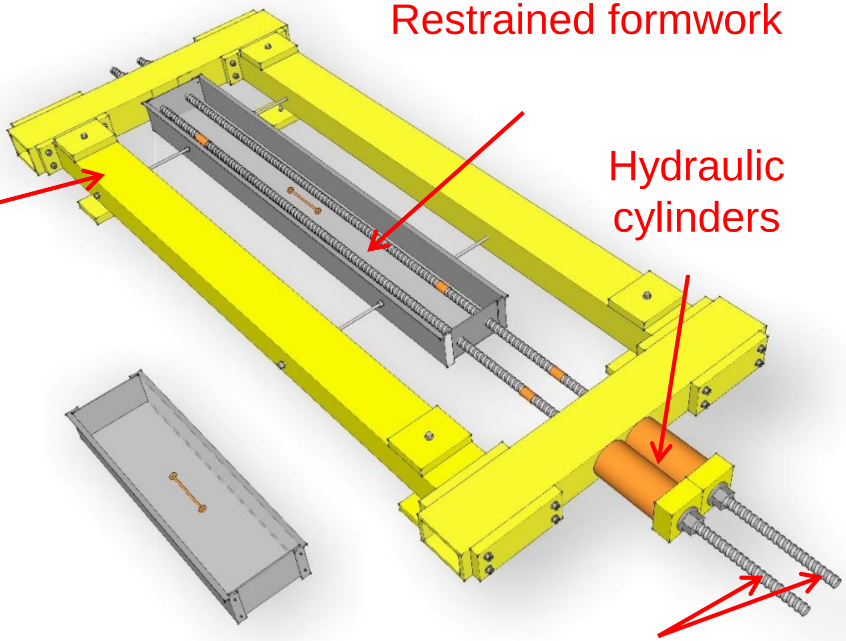
Creep in tension – VRF system

Specimen Concrete + Steel

- ***Steel → Hydraulic transmission of force to the concrete***
- ***Stress induced field of tension in concrete***


Restrained formwork
Hydraulic cylinders
Steel structure
threaded rods

Creep in tension – VRF system

Specimen Concrete + Steel

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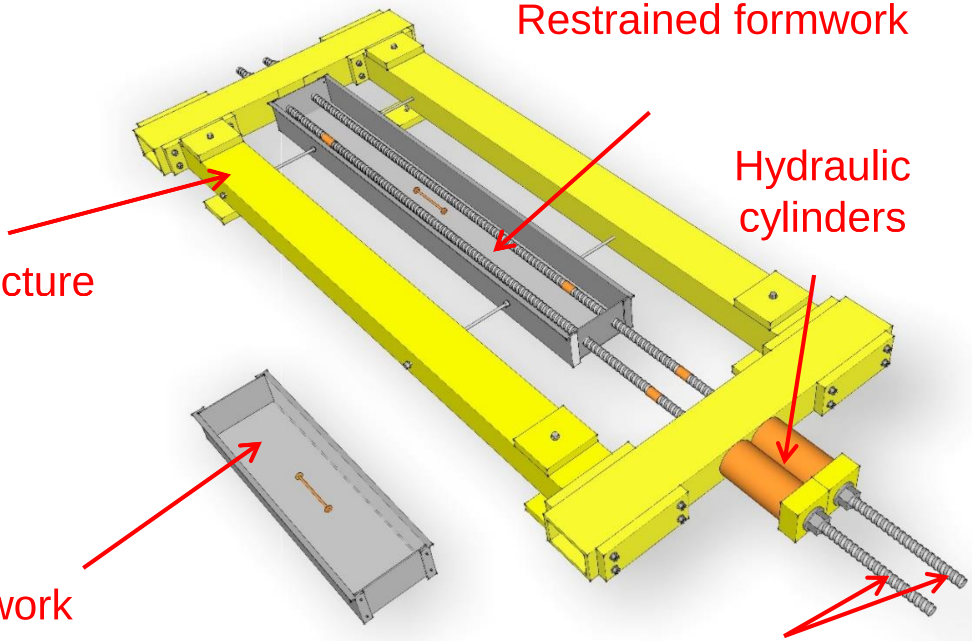


Restrained formwork

Hydraulic cylinders

Steel structure

Dummy formwork

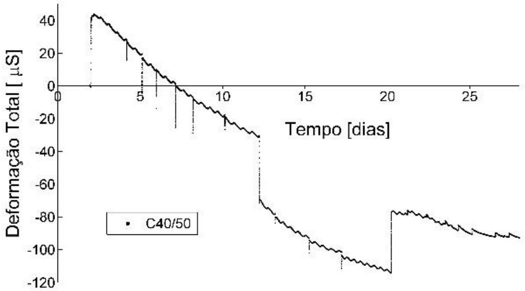
threaded rods

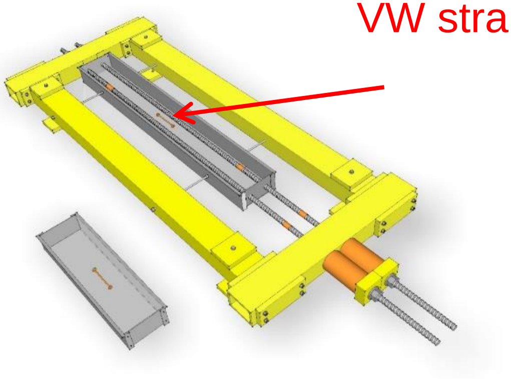
Dummy specimen

- ***Plain concrete***
- ***Free shrinkage***

Basic principle of VRF system

$\varepsilon_{c,total}$

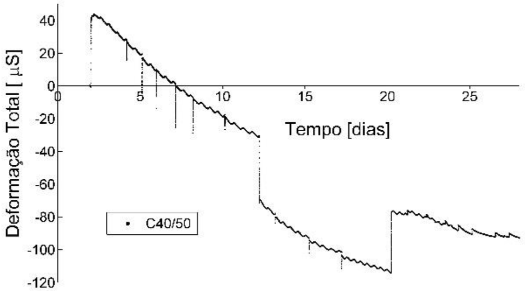




VW strain gauge

Basic principle of VRF system

$\varepsilon_{c,total}$



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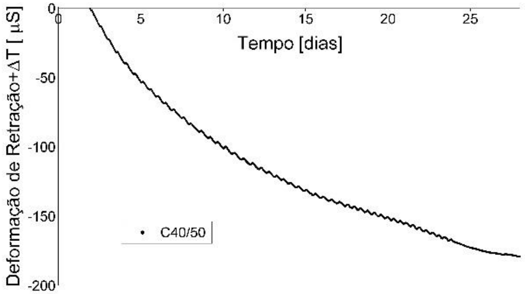
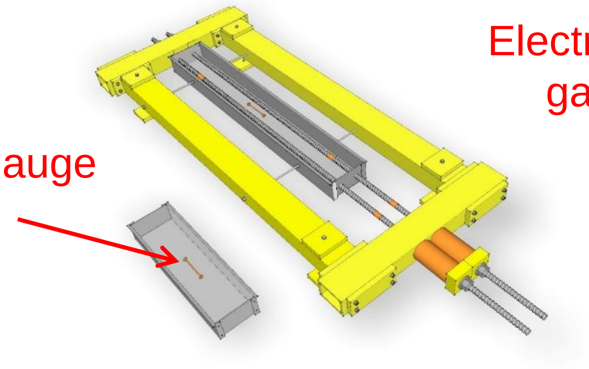
$\varepsilon_{c,\Delta T+Sh}$



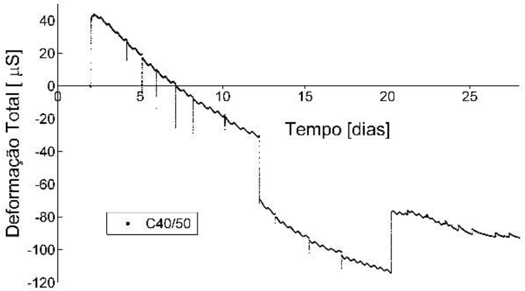


Electric strain gauges

VW strain gauge

Basic principle of VRF system

$\varepsilon_{c,total}$



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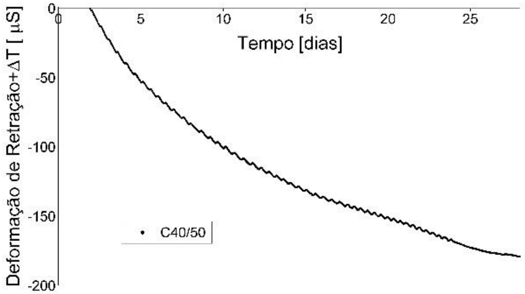
$\varepsilon_{c,\Delta T+Sh}$



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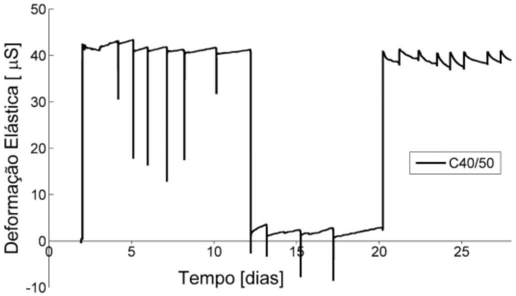
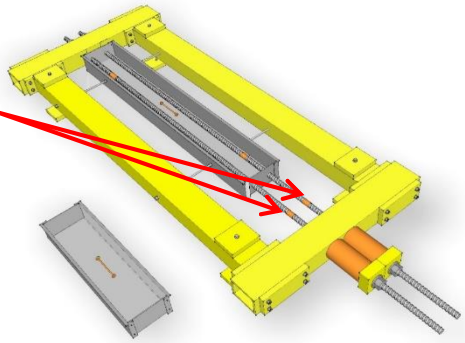
$\varepsilon_{c,elastic}$





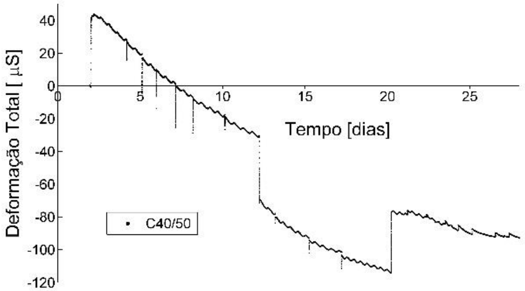
Electric strain gauges

Basic principle of VRF system

$\varepsilon_{c,total}$

$\varepsilon_{c,\Delta T+Sh}$

$\varepsilon_{c,elastic}$



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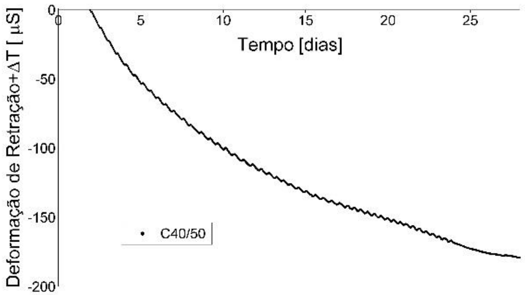

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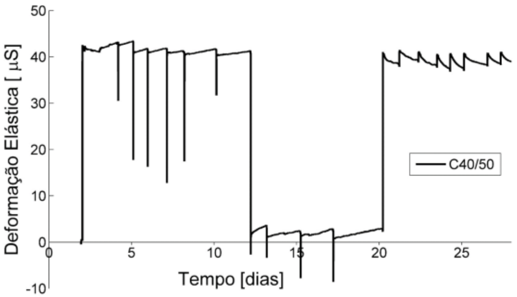

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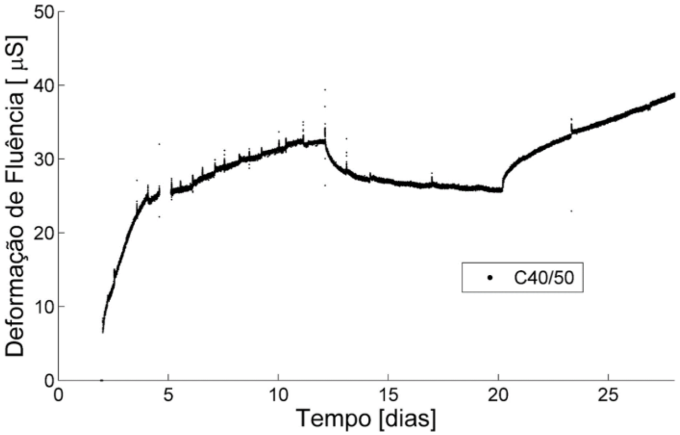
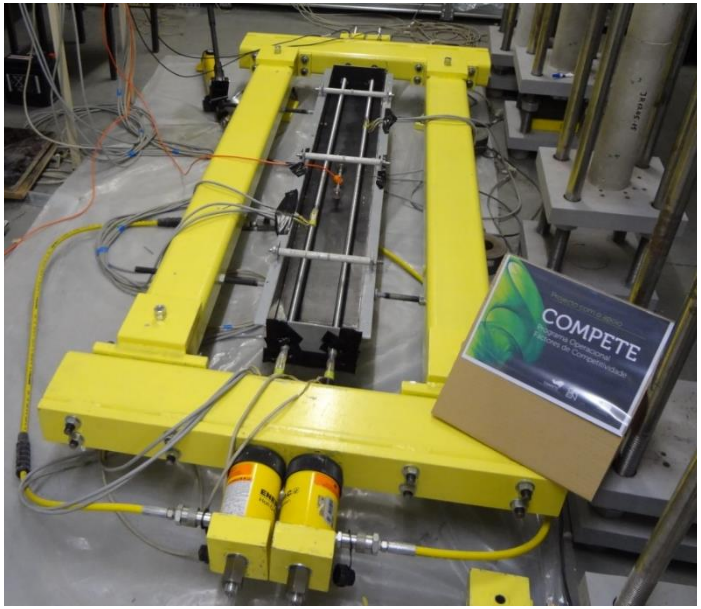
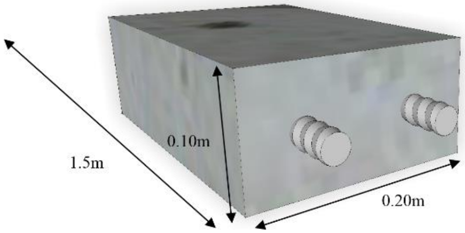
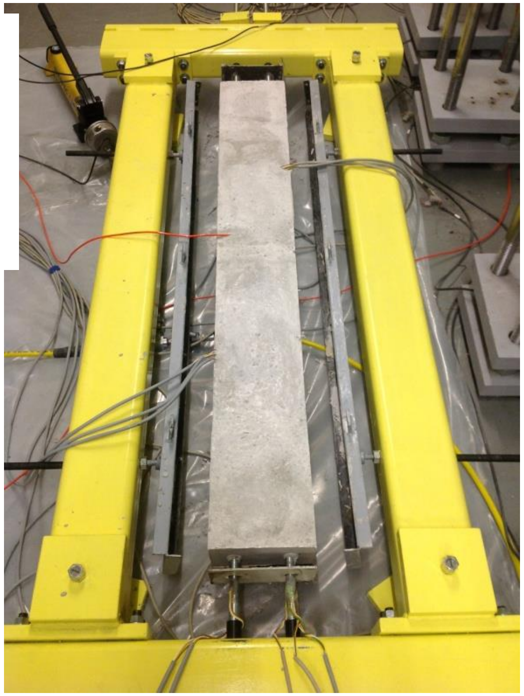


Implemented VRF system / Results

- ***VRF after concreting.***
- ***Formwork system removed.***

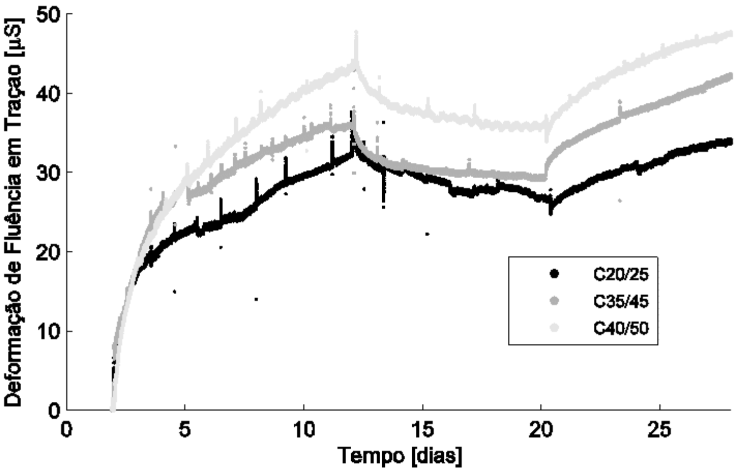



1.5m
0.10m
0.20m

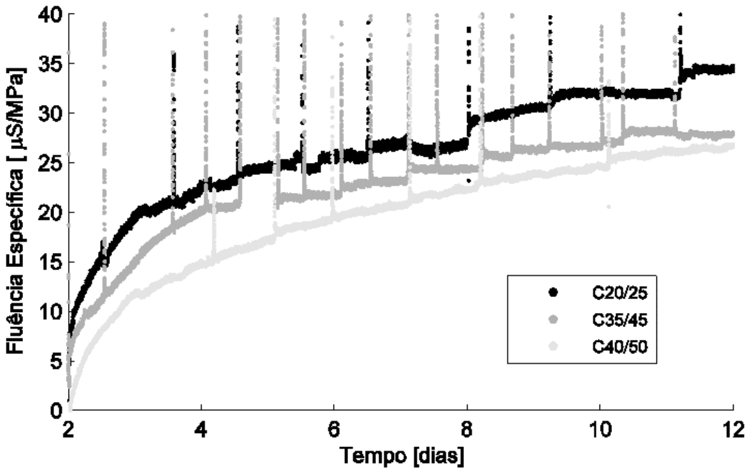


Implemented VRF system / Results

Creep strain

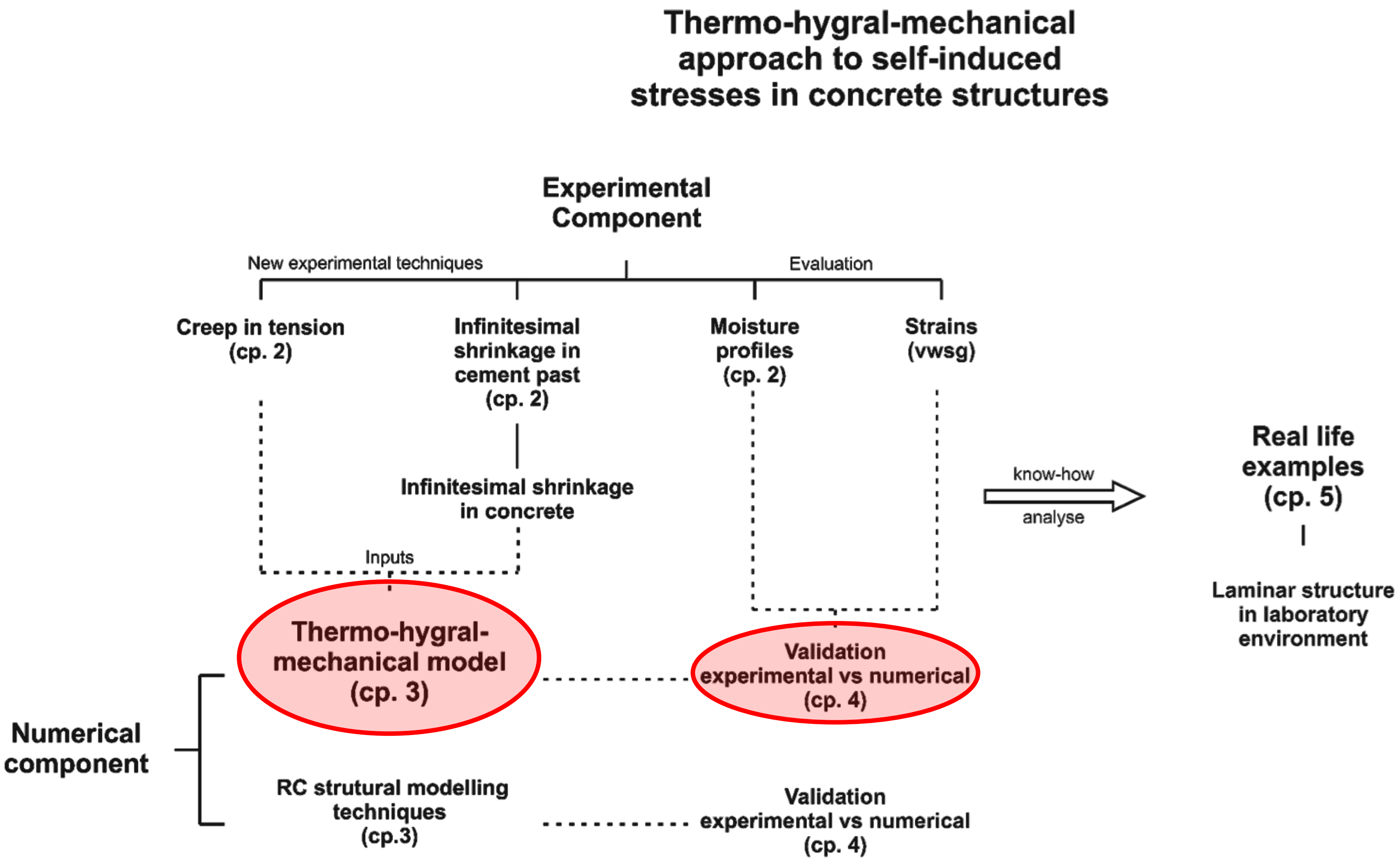


Specific creep



- ***High precision curves – considerable difference compared to the associated literature.***
- ***Lower resistance class of concrete ⇒ higher specific creep.***

Validation THM model



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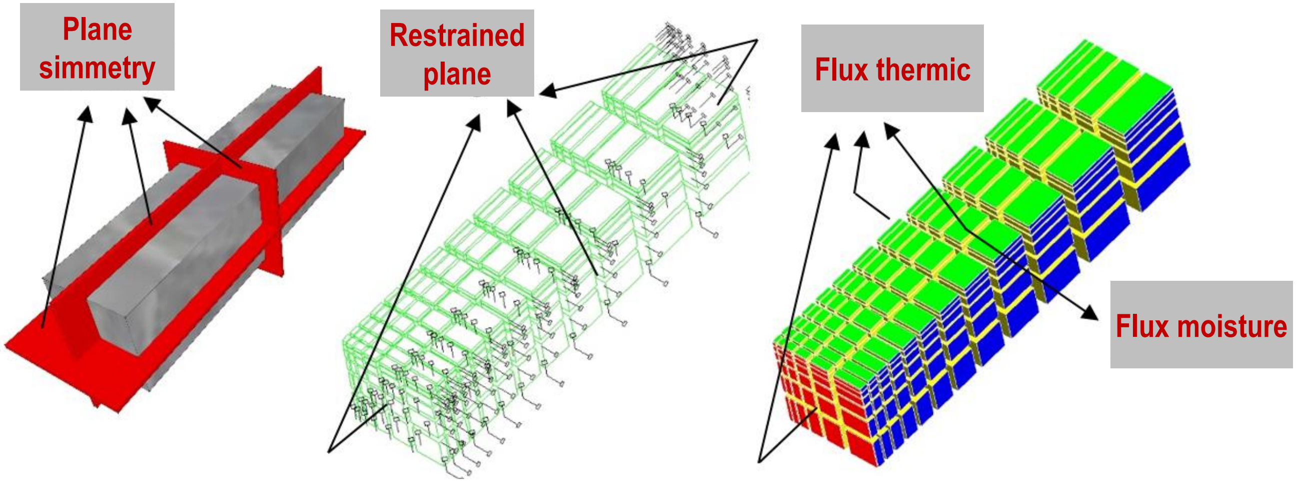
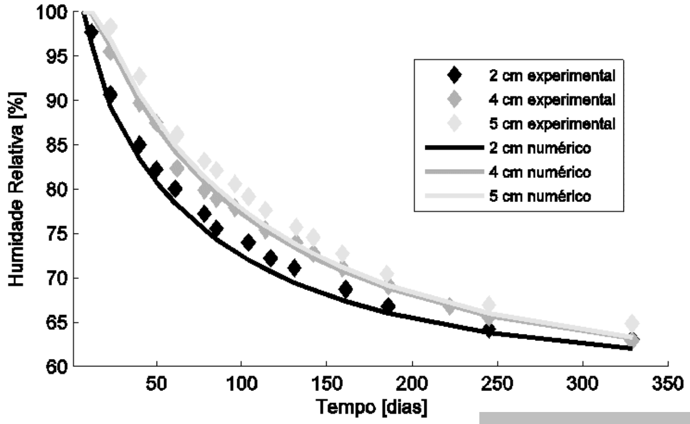
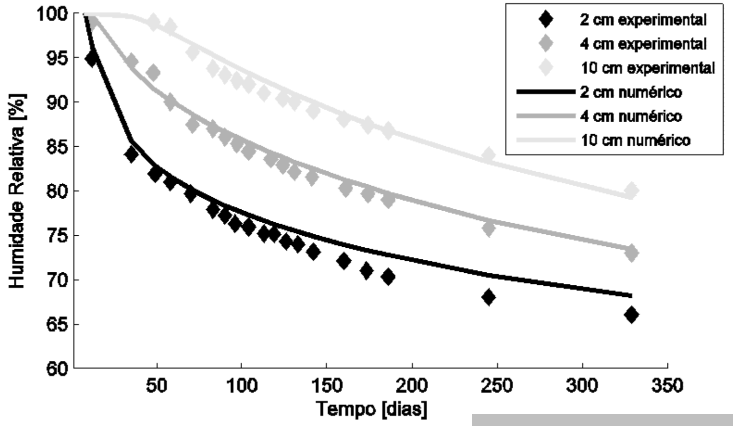

Plane simmetry
Restrained plane
Flux thermic
Flux moisture

- ***Pre-processing of THM model possible in software DIANA.***
- ***Refinement of FE mesh in areas with higher thermic and moisture flux***

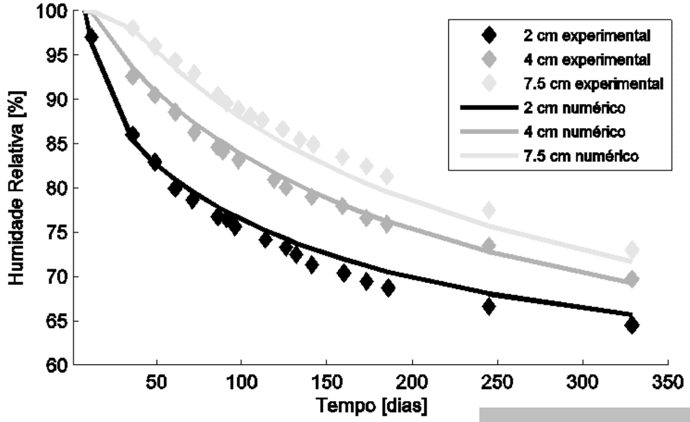
Validation THM model



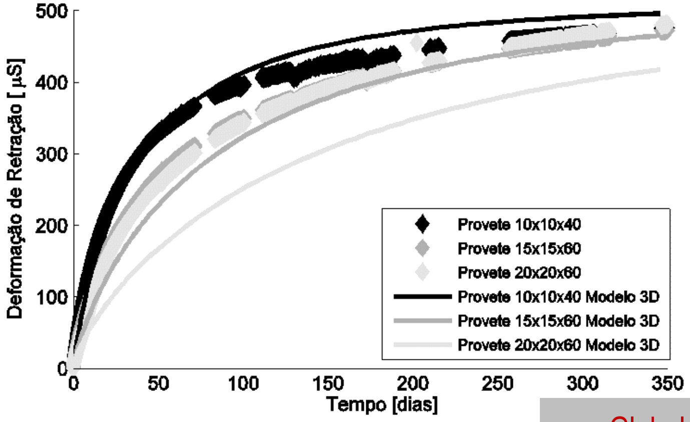
Specimen internal moisture 10x10x40cm^3



Specimen internal moisture 15x15x60cm^3

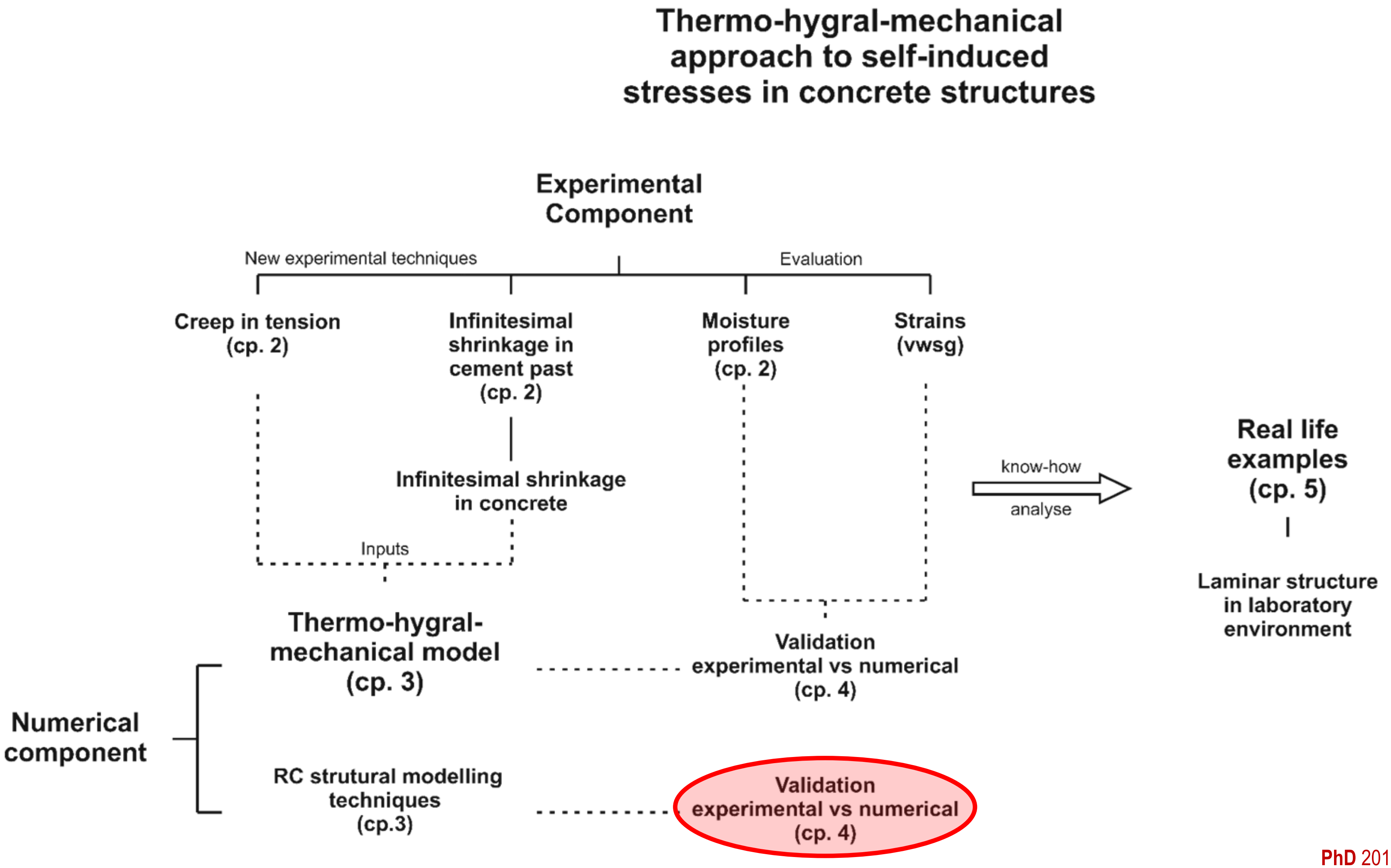


Specimen internal moisture 20x20x60cm^3



Global strain

RC strutural modelling techniques



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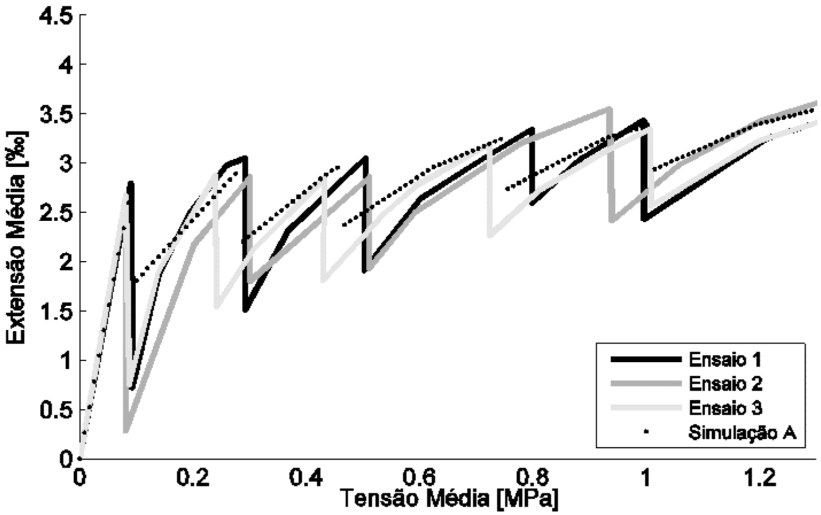
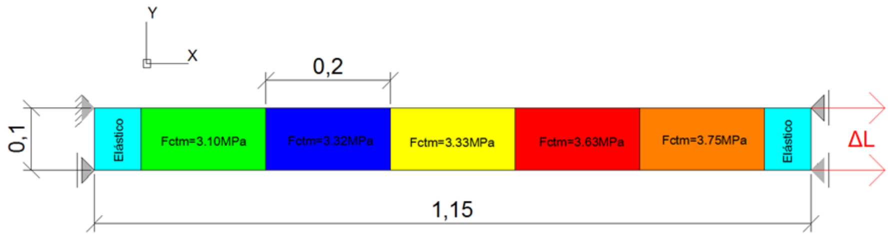
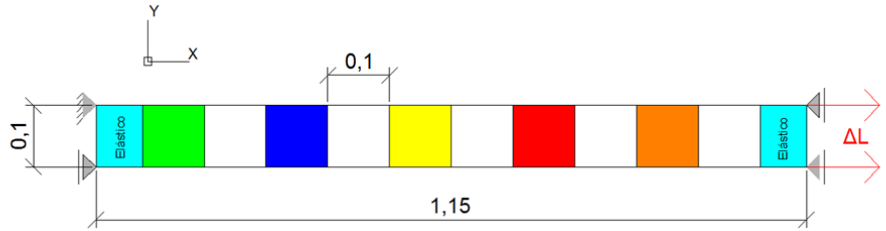


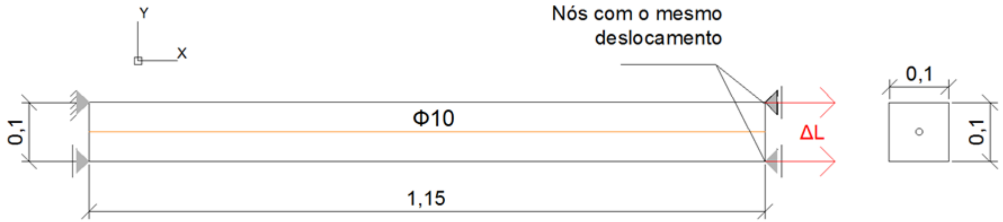
Experimental vs numerical results


Y
X
0,2
0,1
Elástico
Fctm=3.10MPa
Fctm=3.32MPa
Fctm=3.33MPa
Fctm=3.63MPa
Fctm=3.75MPa
Elástico
ΔL
1,15

FE mesh model A

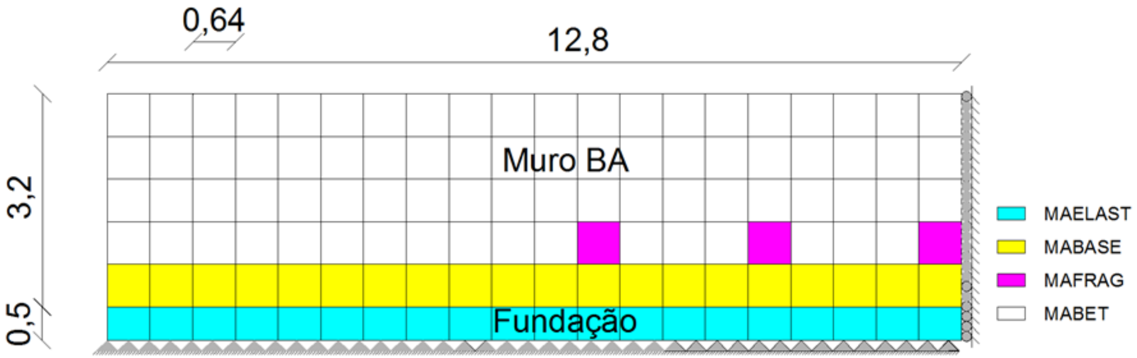

Y
X
0,1
0,1
Elástico
Elástico
ΔL
1,15

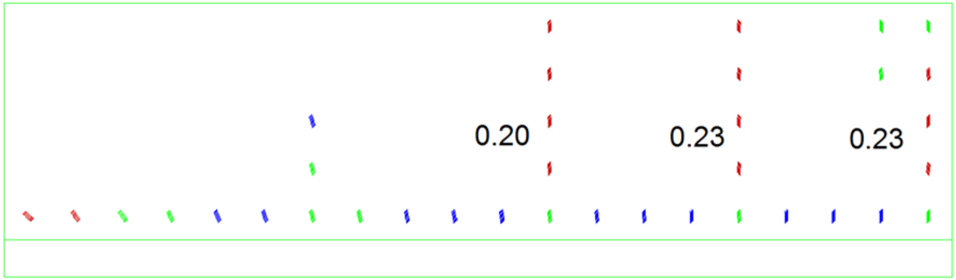
FE mesh model B


Y
X
Nós com o mesmo
deslocamento
Φ10
0,1
ΔL
1,15
0,1
0,1

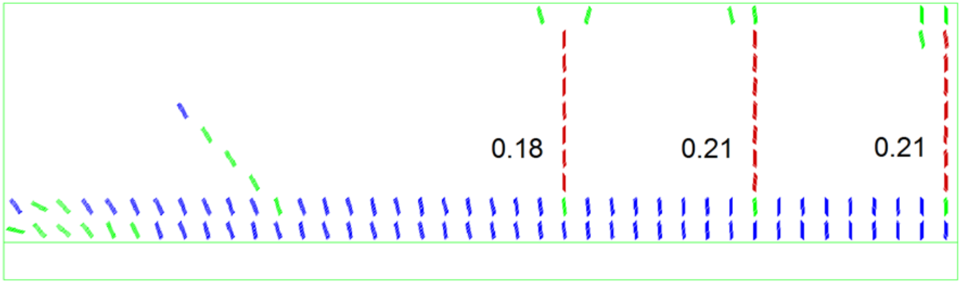
Numerical model

RC strutural modelling techniques


0,64
12,8
3,2
0,5
Muro BA
Fundação
MAELAST
MABASE
MAFRAG
MABET

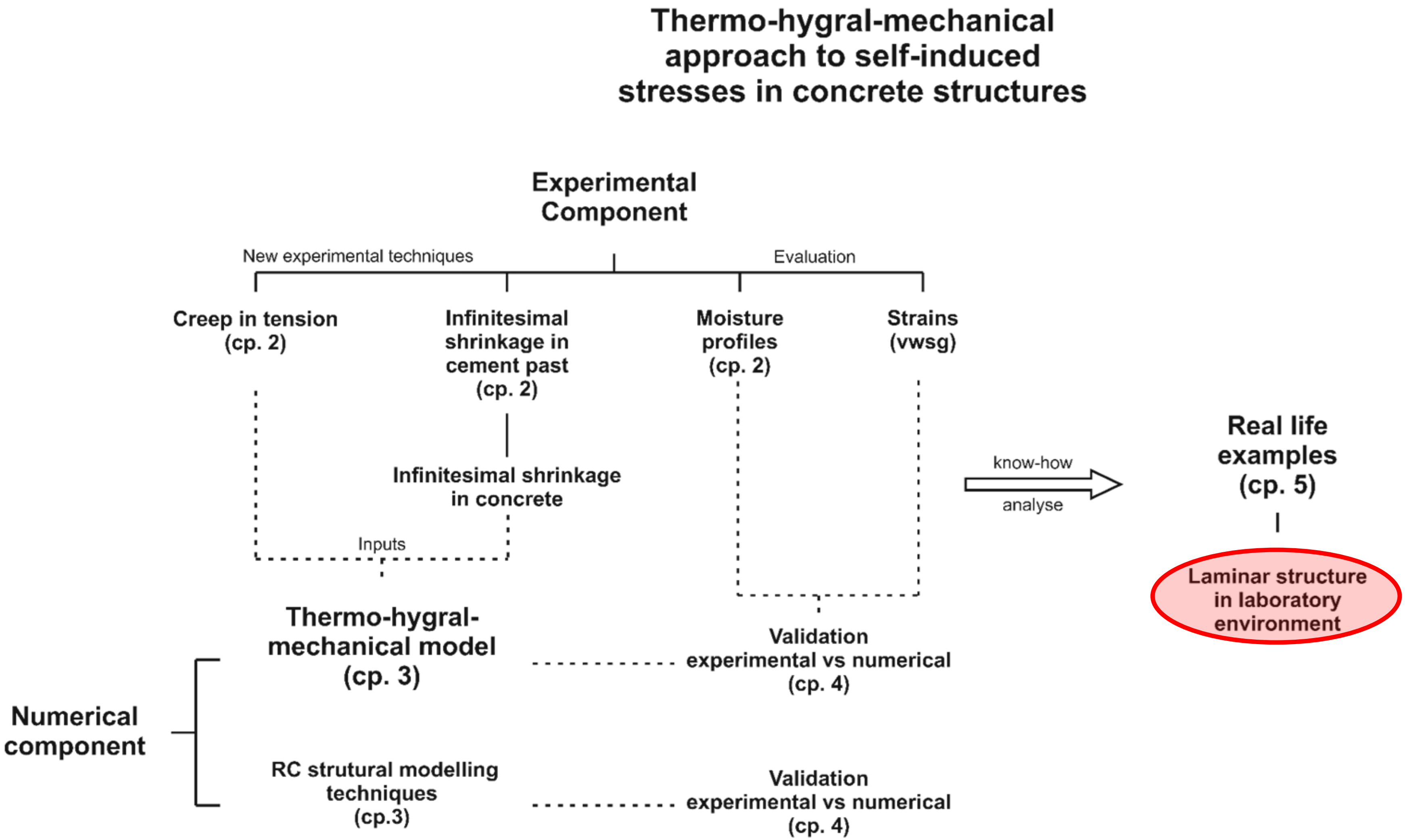


Model A



Model B

Laminar Structure in Lab. Environment



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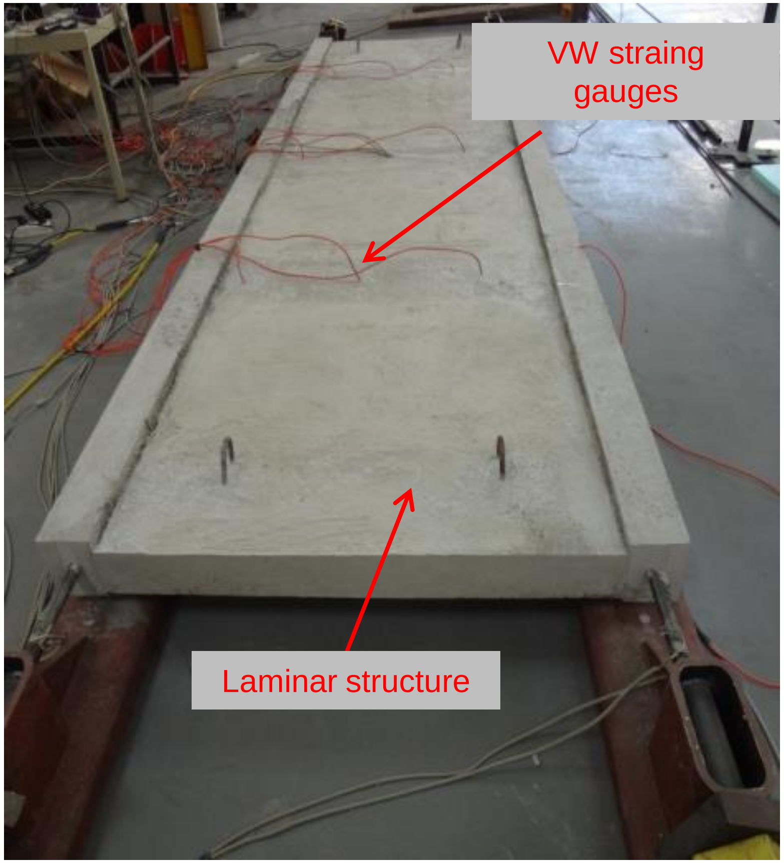
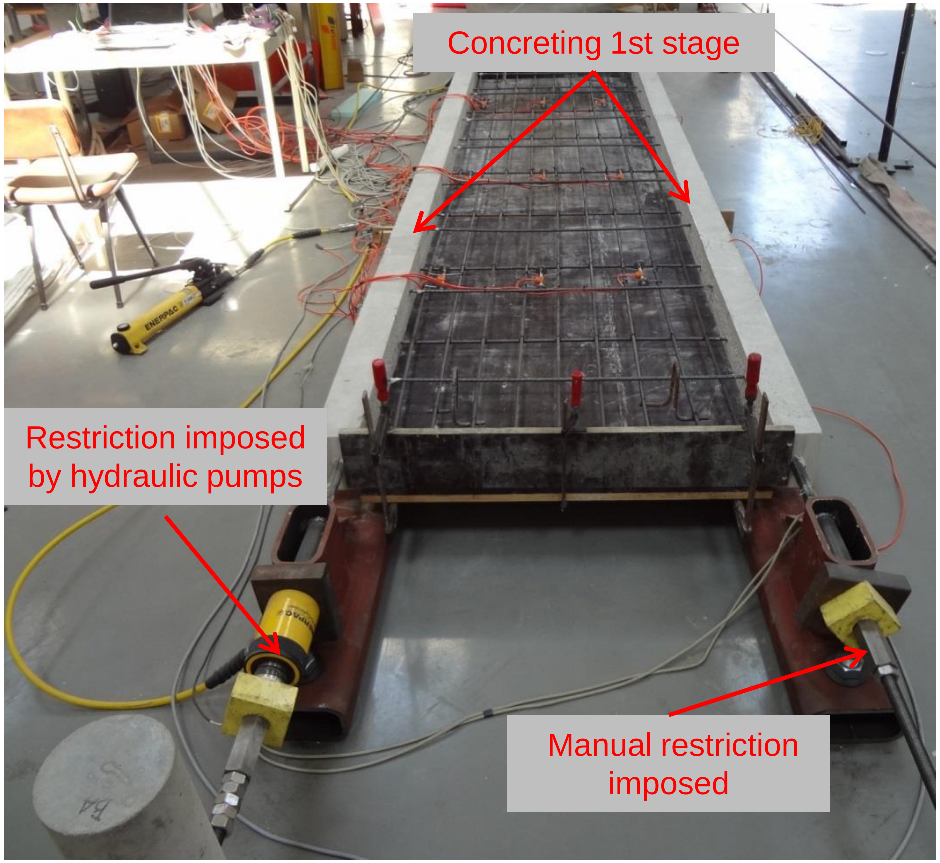
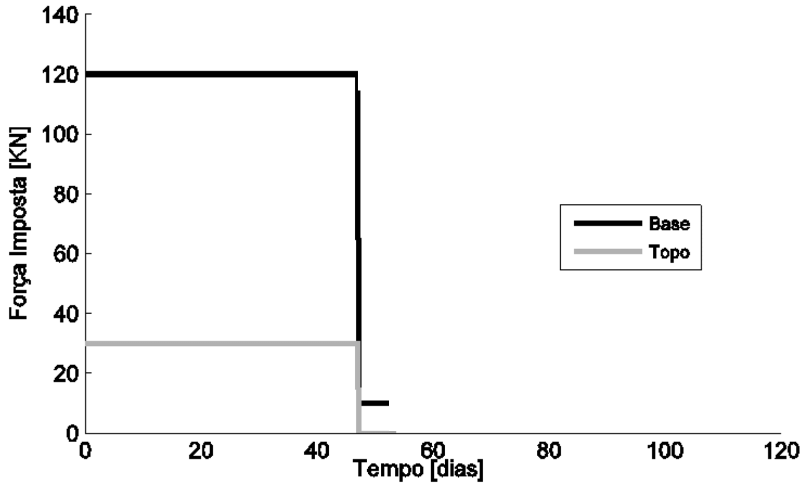
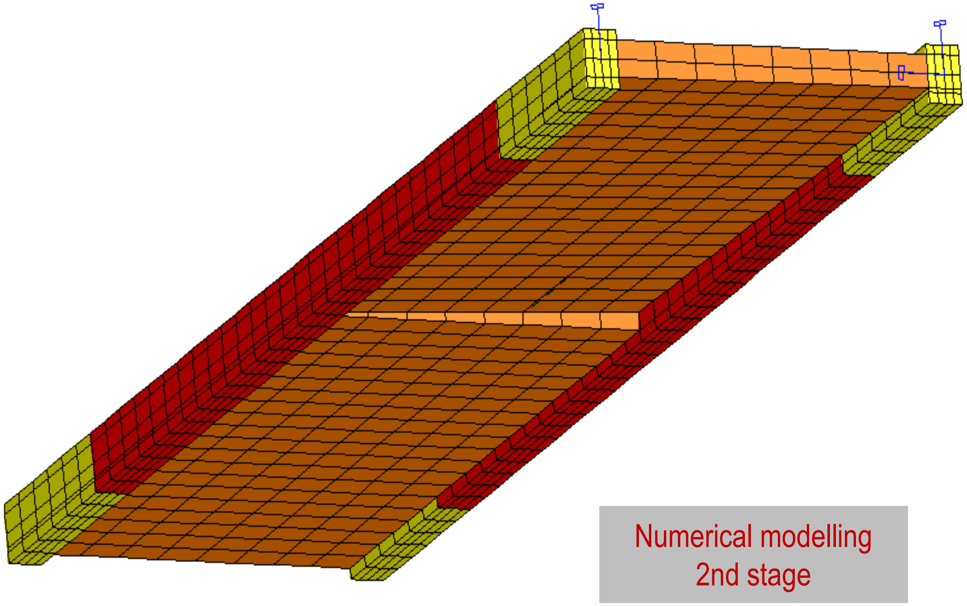

VW straing gauges
Laminar structure


Concreting 1st stage
Restriction imposed by hydraulic pumps
Manual restriction imposed

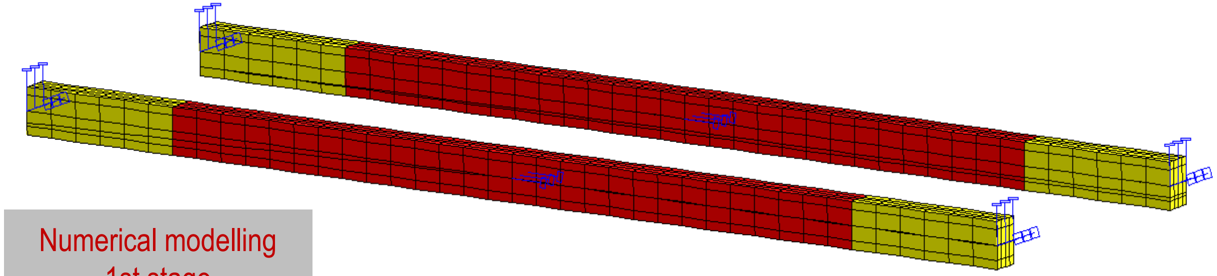
Laminar Structure in Lab. Environment



Load evolution in restricted areas



Numerical modelling 2nd stage



Numerical modelling 1st stage

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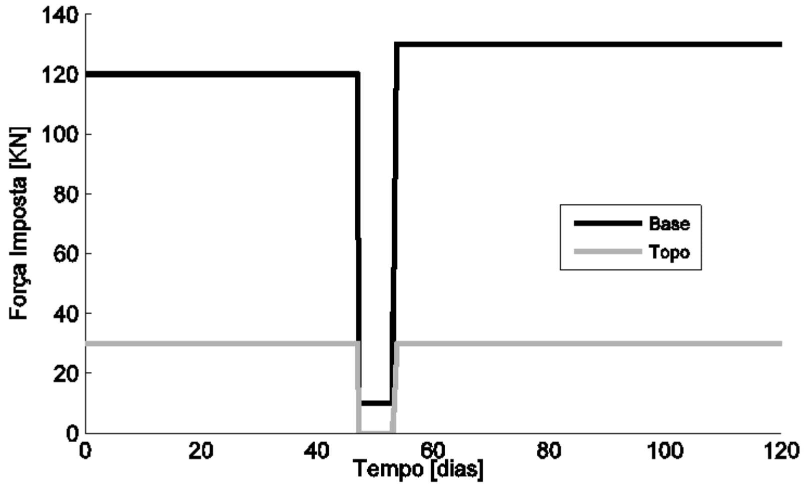

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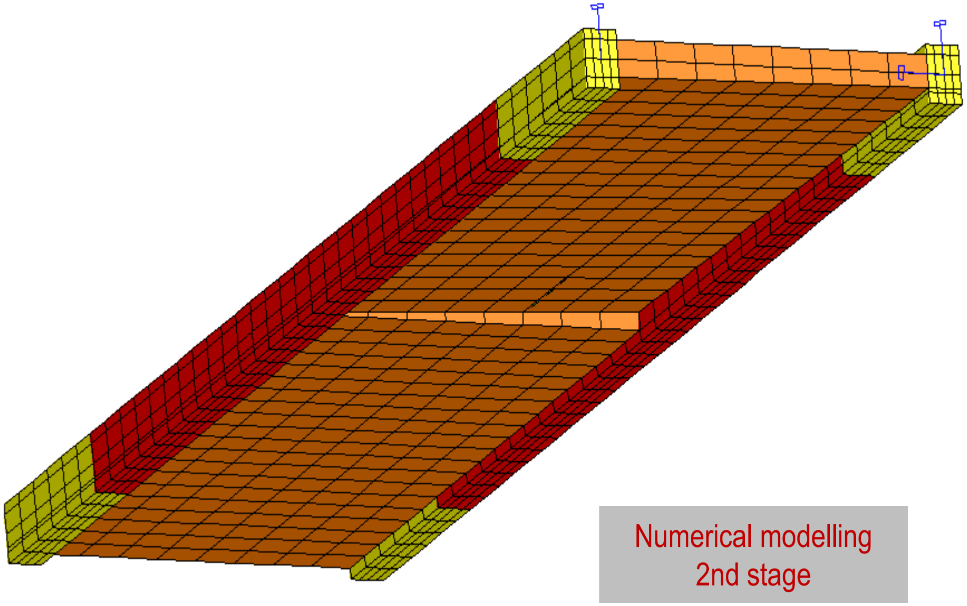
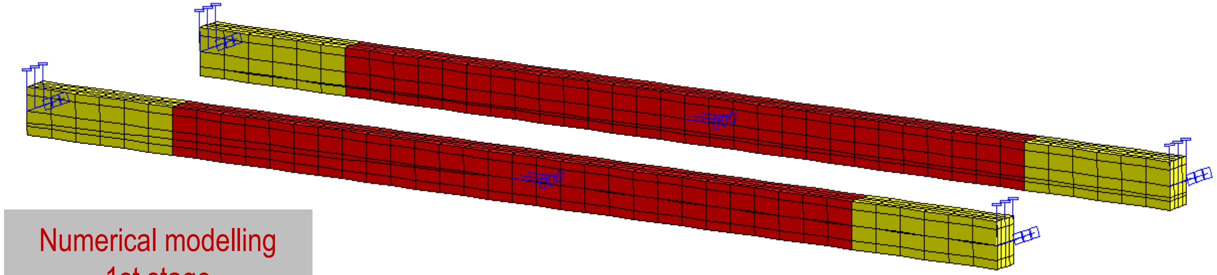
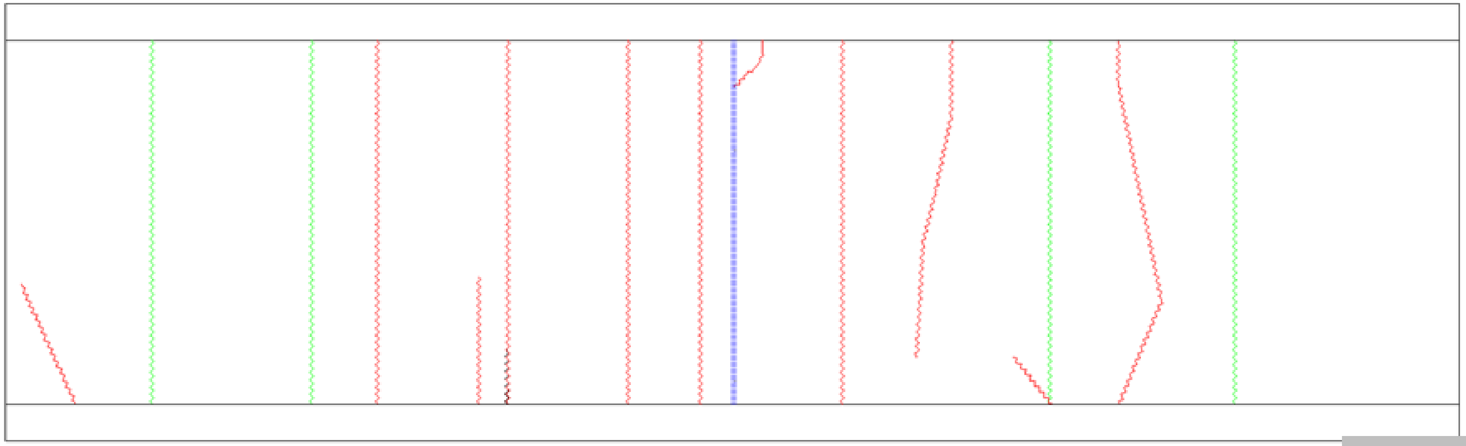


Numerical modelling 2nd stage

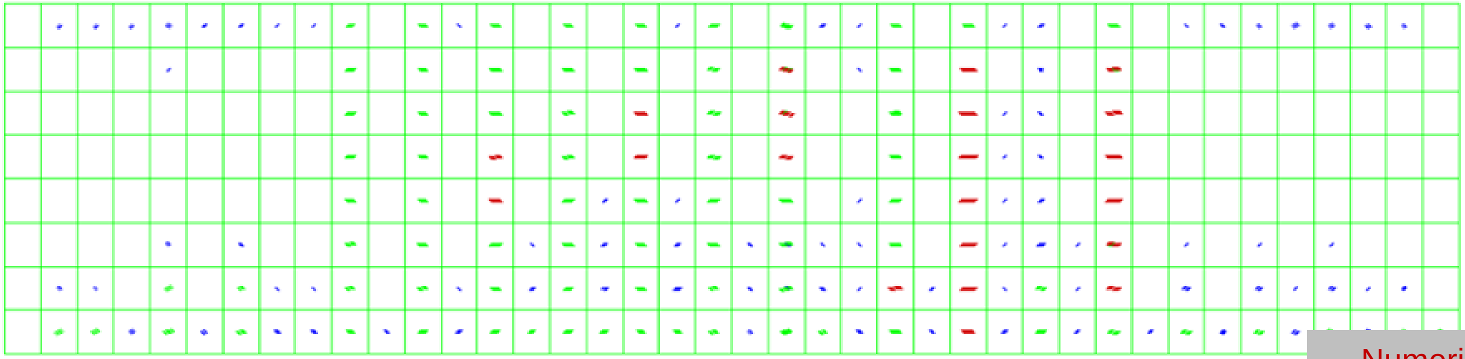


Numerical modelling 1st stage

Laminar Structure in Lab. Environment



Real cracking pattern: 120 days



Numerical cracking pattern: 120 days