Creep and moisture interaction on tropical timber structures under outdoor conditions: spatial variability of mechanical parameters

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❑ Context

Related Products

Wood sawed

First industry of wood's transformation

Individual or collective houses

❑ Problems

- **Various species :** Baillonella (Moabi), Acoumea Pierre (Okoumé)….
- **Mechanical behavior:** drying process, nodes, creep, fracture processes…
- **Difficult to use in building** (Thermo-hydro-visco-mechanical)

Main goals

- Know the impact of the climatic variations and creep on the mechanical behavior of the structure in tropical environment
- Characterizing and modelling the spatial variability of the physical-mechanical parameters under tropical climate

specific goals

- Creep tests on beams in outdoor and sheltered conditions
- Bending/compressive test on specimens coming from these beams
- Characterizing and modelling the randomness and spatial variability of wood properties : density and mechanical properties

1. Context & goals

2. Materials & Methods

3. Results

Conclusion & Outlook

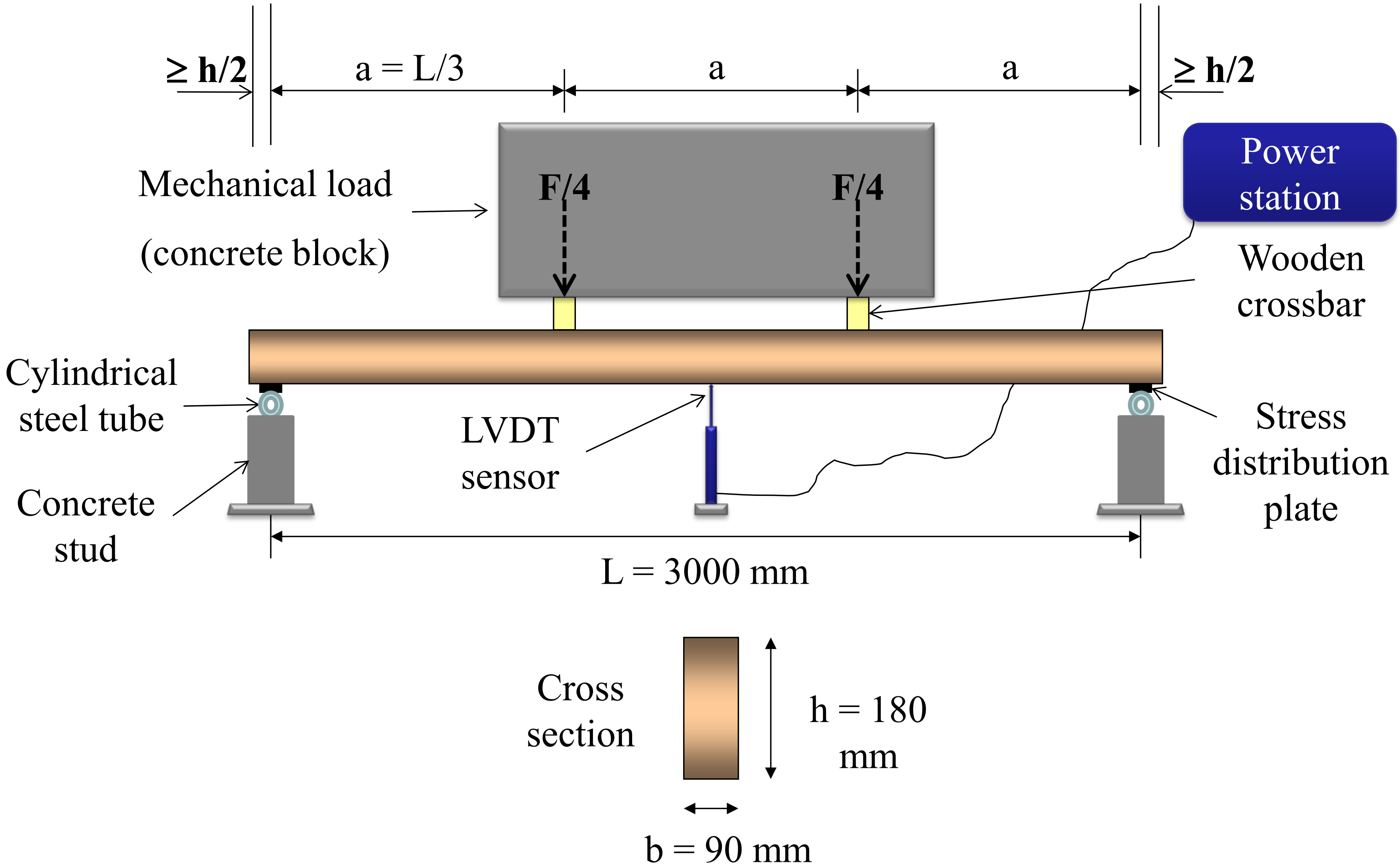
- **Materials:**

Concrete loading (10 kN)

Moabi specie or *Baillonella Toxisperma*

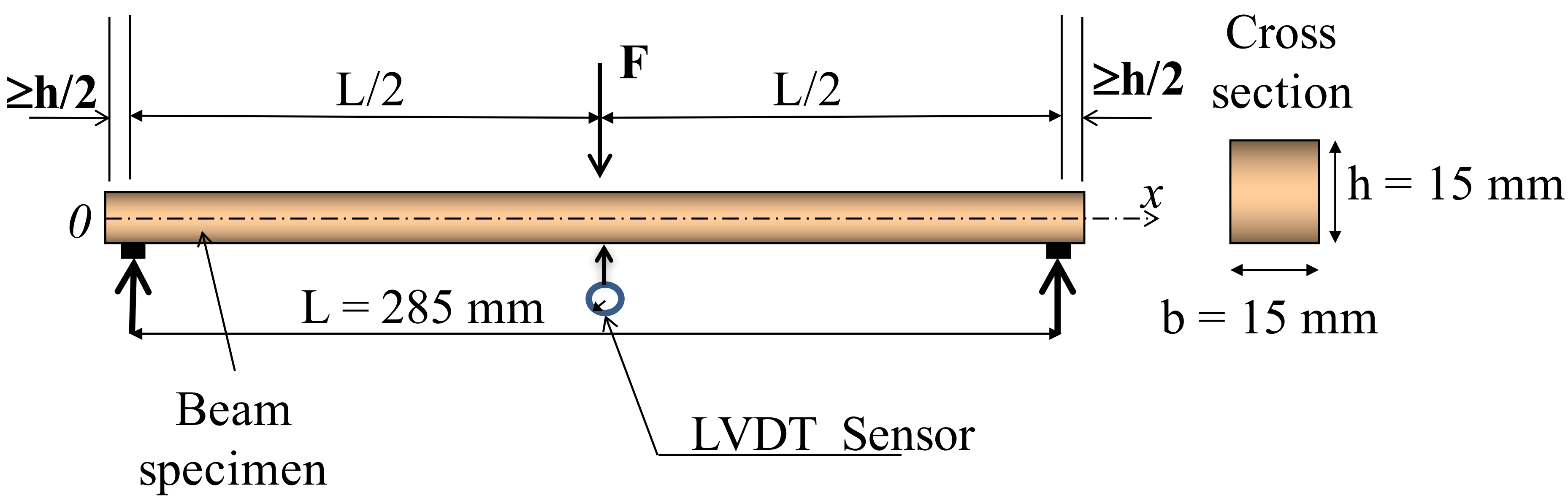
Beam in sheltered outside climate

- Configuring test specimens for creep tests:



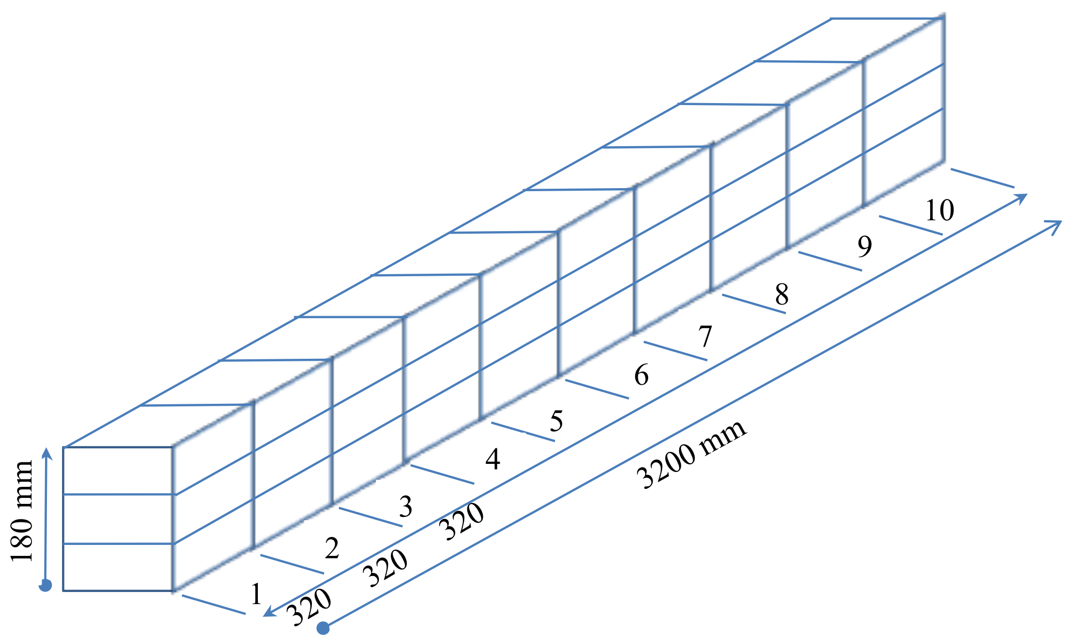
Experimental devices

- Configuring test specimens for instantaneous tests:

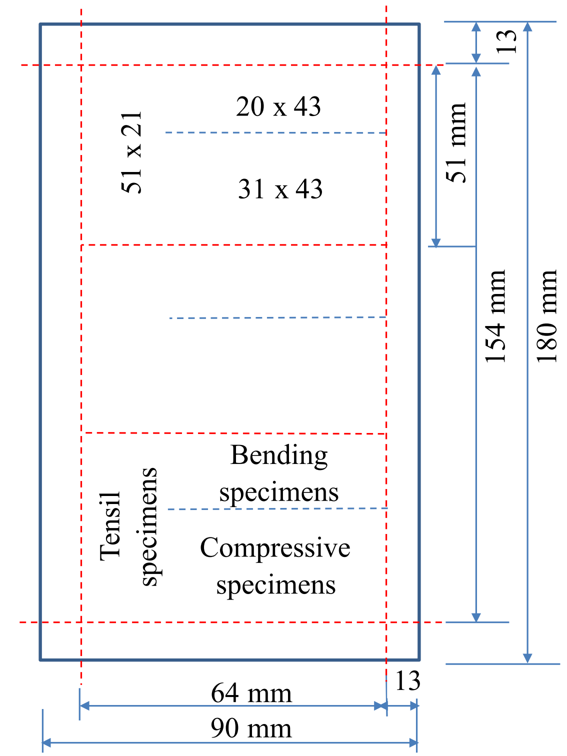


Modelling of experimental device for bending test

- Experimental devices



Modelling of spatial distribution of specimens (different trajectories)



Dimensions of specimens for bending and compressive tests

➢ Reliability approaches

- Uncertainties and spatial variability ➙ material properties, environment, loads, etc.

- Spatial variability characterization and modelling ➙ material properties

- Karhunen-Loève expansion

$$X(x,\theta) = \mu_X + \sigma_X \sum_{i=1}^{n} \sqrt{\lambda_i}\, \xi_i f_i(x)$$

where : n : number of terms of the expansion
ξ_i: Gaussian random variables
λ_i, f_i : eigenvalues and Eigen-functions of the autocorrelation function $\rho(\Delta x)$

- The exponential correlation function ➙ represent the autocorrelation shape of the material properties (Sudret and Kiureghian 2000; Rakotovao *et al.* 2017)

$$\rho(\Delta x) = \exp\left(\frac{-|\Delta x|}{b}\right)$$

where b is the correlation length

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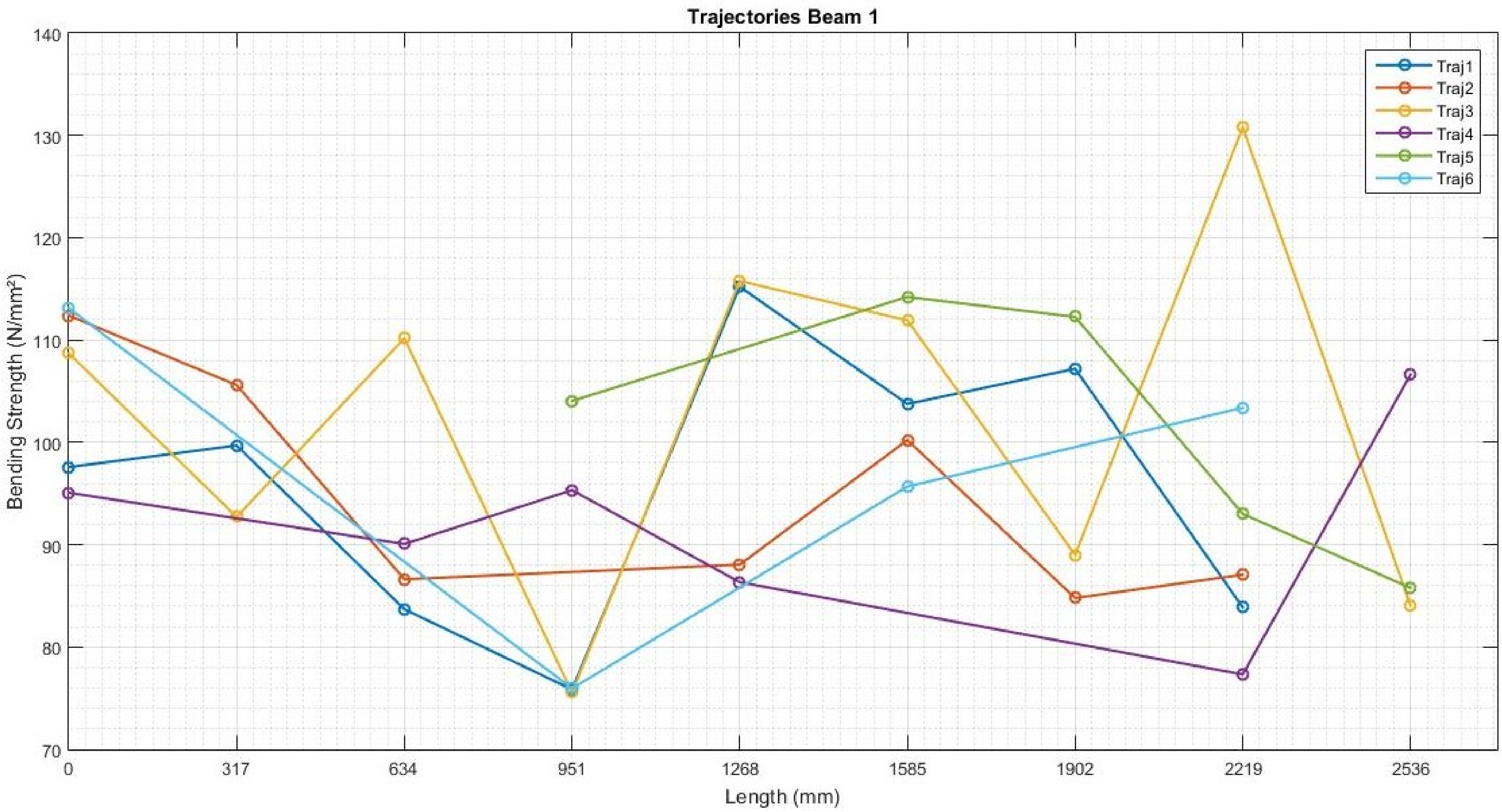
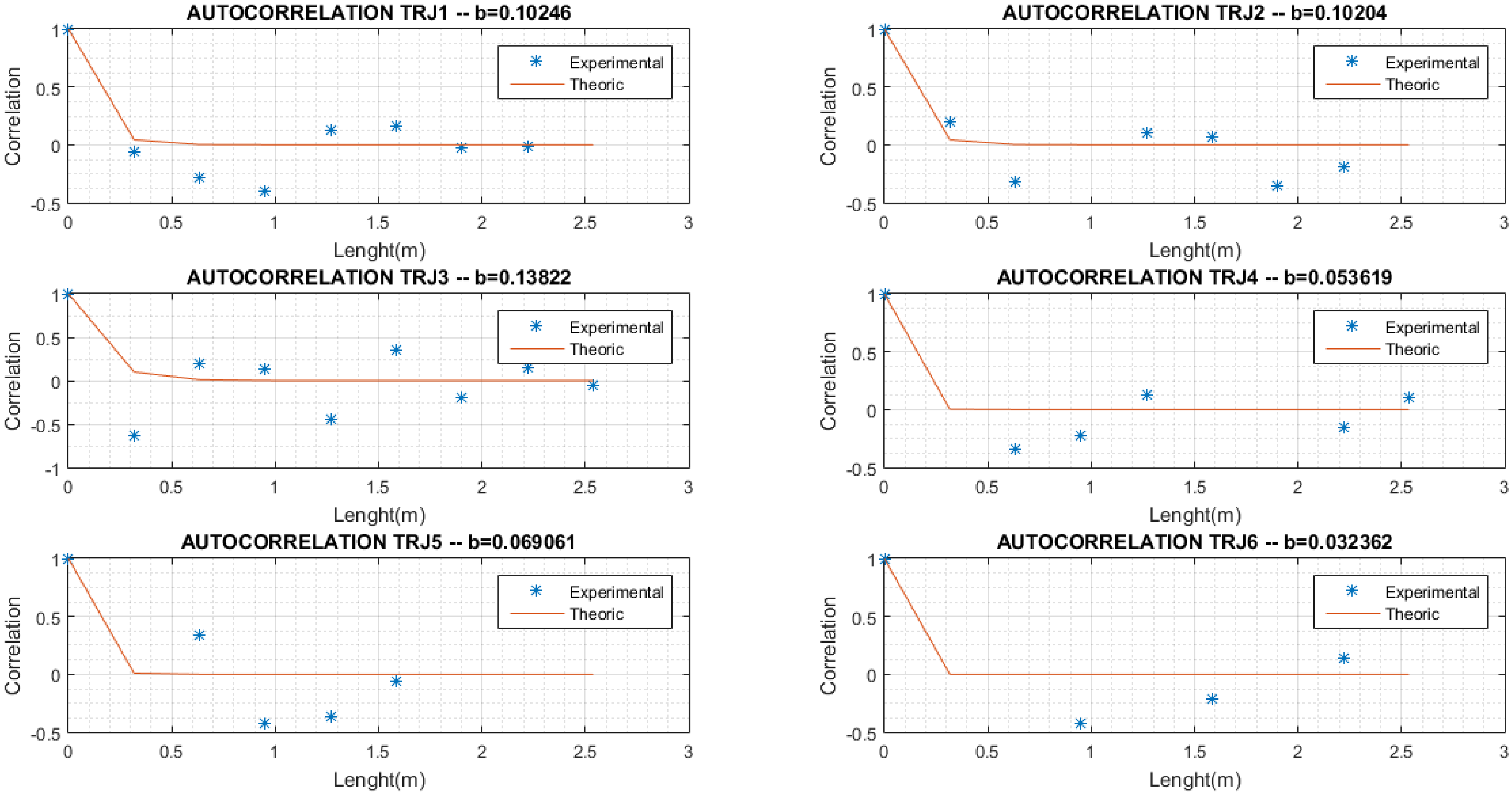
Experimental measurements for Bending strength



Mean and Standard deviation of Bending Strength after filtering (N/mm^2)

Traj	B1 μ	B1 σ	B2 μ	B2 σ
1	95.8638	13.4957	106.5550	4.5941
2	94.9714	11.0100	105.4900	8.3643
3	102.0833	17.6942	115.8000	6.3129
4	91.7983	9.8496	116.7320	6.4451
5	101.8700	12.2734	119.1825	7.3306
6	97.0375	15.7560	116.9320	6.8407

Autocorrelation of Bending Strength trajectories



$$\rho(\Delta x) = \exp\left(\frac{-|\Delta x|}{b}\right)$$

Autocorrelation lengths of Bending Strength (in m)

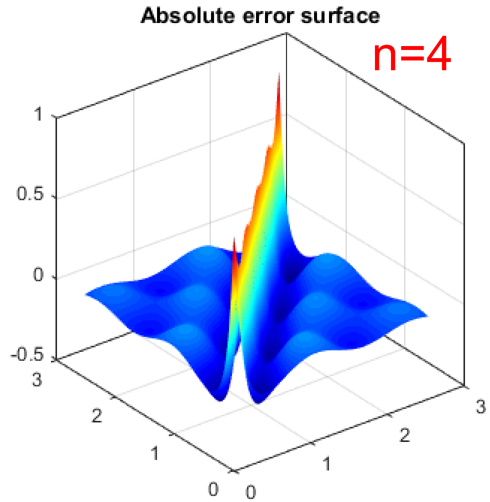
Traj	b for BS1	b for BS2
1	0.1025	0.0499
2	0.1020	0.0572
3	0.1382	0.0678
4	0.0536	0.0656
5	0.0691	0.0623
6	<u>0.0324</u>	0.0671

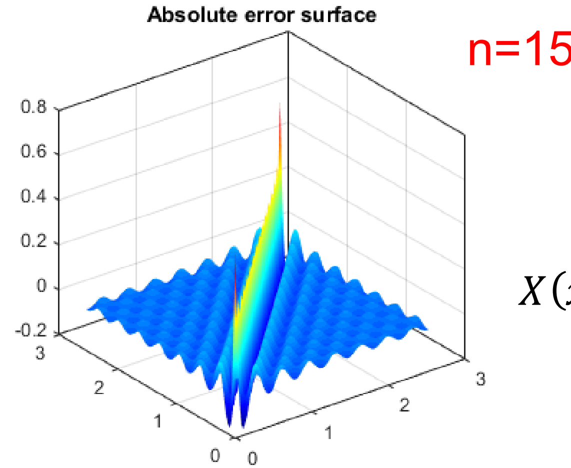
Summary of data identified for modelling the random field (*b* in m and μ, σ in N/mm^2)

BEAM	b	μ_X	σ_X
BS1	0.09308	97.2707	4.0394
BS2	0.0616	113.4486	5.8683

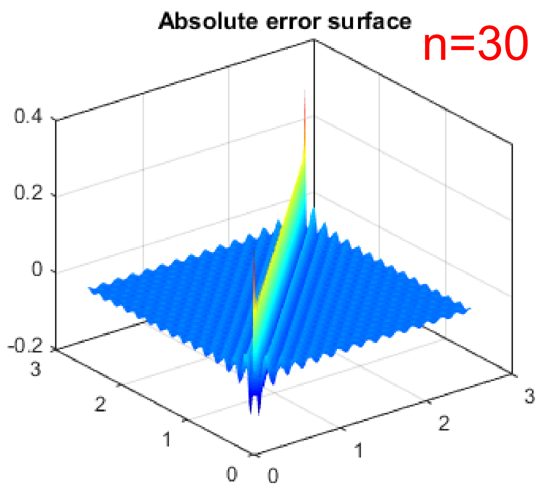
$$X(x,\theta) = \mu_X + \sigma_X \sum_{i=1}^{n} \sqrt{\lambda_i}\, \xi_i f_i(x)$$

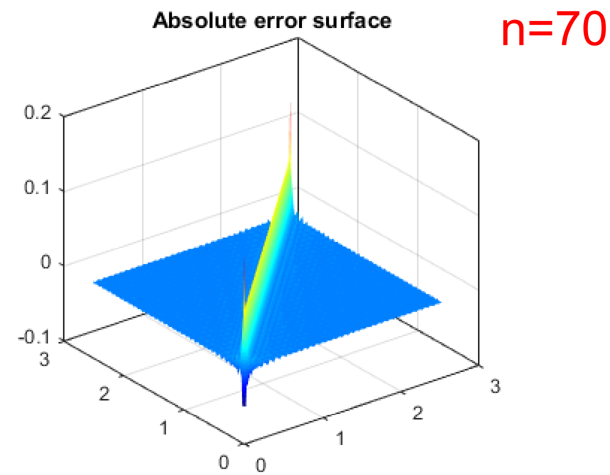
Absolute error of the process covariance with respect to experimental data



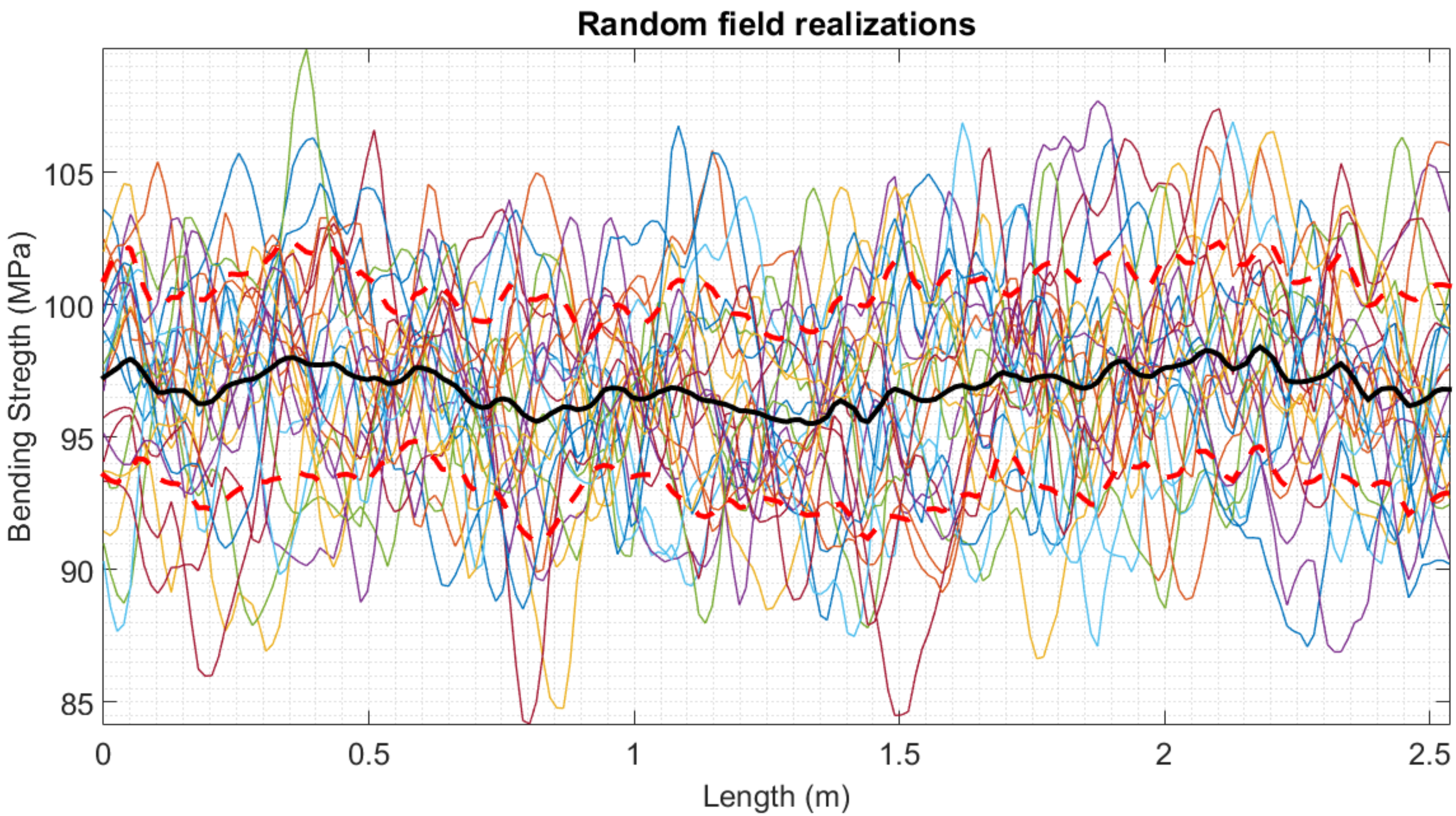


$$X(x,\theta) = \mu_X + \sigma_X \sum_{i=1}^{n} \sqrt{\lambda_i}\,\xi_i f_i(x)$$





With a higher order of expansion we obtain better approximations, minimizing error.



Realizations of the random field of bending strength generated from the Karhunen Loeve expansion

Improve the reliability assessment of timber components by considering the randomness and spatial variability

❑ The first results show

- ✓ Tests on beam in sheltered tropical atmosphere (Moabi)
- ✓ Tests specimen debited of these beams according Eurocode requirements
- ✓ Tests in compressive in order to know the of young modulus and density
- ✓ Tests in bending in order to know the of young modulus and density
- ✓ The bending moment could be represented by a stationary random field and modelled by using the Karhunen-Loève expansion

❑ Coming works

- ✓ Perform the same tests on tensile conditions
- ✓ Perform the same tests on beam in outside and inside conditions
- ✓ Consider uncertainty and spatial variability processes in a reliability analysis

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