RISK-BASED ANALYSIS OF BRIDGE SCOUR PREDICTION WITH LIVE BED CONDITIONS

Second year workout

Ana Margarida Bento

Supervisors: Dr. Teresa Viseu (LNEC); Dr. Lúcia Couto (LNEC); Dr. João Pedro Pêgo (FEUP)

Outline

- Introduction
- Objectives
- Work Done
- Work in Progress
- Planned Work
- Work Status

Introduction

Schoharie Creek, NY, USA, 1987

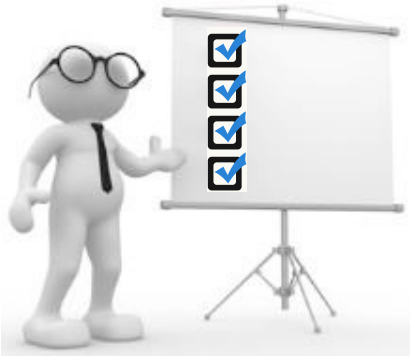
Hintze Ribeiro bridge, Portugal, 2001

Objectives

Develop a **risk-based method** for probabilistic **prediction of bridge scour depth** under **clear water** and **live bed** conditions

- Experimental Work
  - Turbulent flow field
  - Scour hole geometry evolution
- Numerical Modelling
  - Flow field and scour patterns
  - Portuguese bridge(s)
- Risk-based Analysis
  - Scour prediction formulas
  - Hydrologic and hydraulic features

Work Done

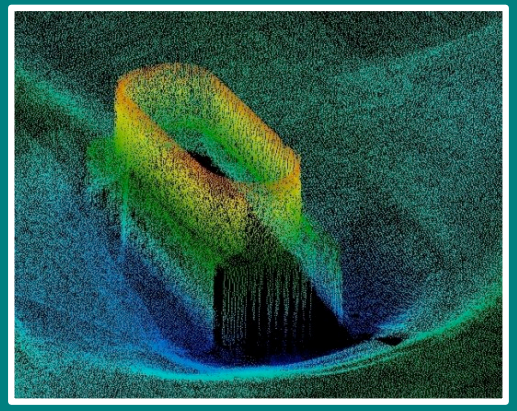


Adaptation of the tilting flume at LNEC's Pavilion

Conduction of trial runs using sophisticated instrumentation

Definition of the experimental campaign, procedure and measuring techniques

Selection of the appropriate **CFD tool(s)** for simulating the **flow field** and **scour patterns**

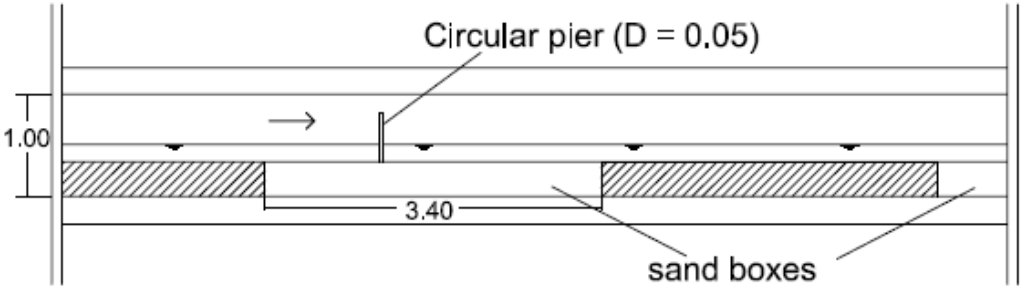


Selection of Portuguese bridges as case studies

Flume at LNEC
(40 m long and 2 m wide)

Flume at FEUP
(32.2 long and 1 m wide)

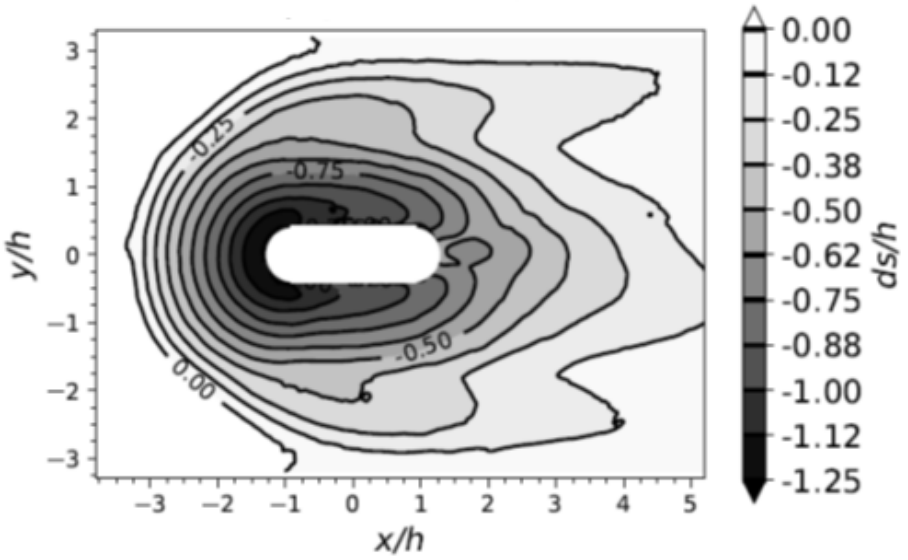
Scour hole at pier vicinity
(W = 14 cm; ds = 23 cm - 3 days)



(Dimensions in meters)

River Flow 2018

NINTH INTERNATIONAL CONFERENCE ON FLUVIAL HYDRAULICS

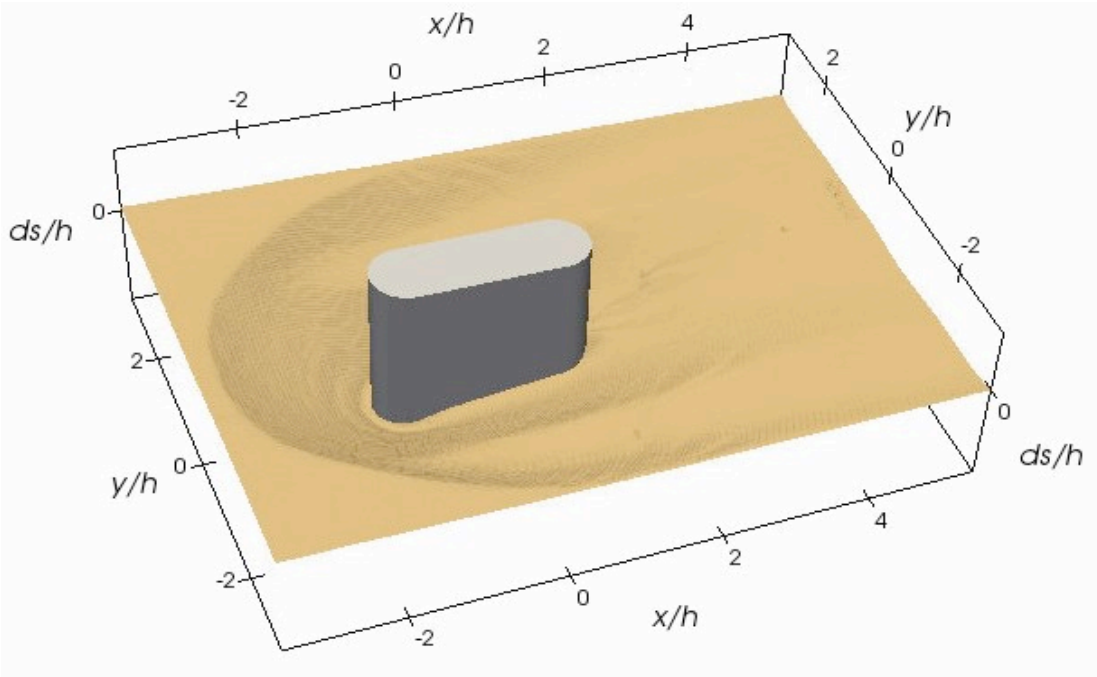


Main features:

- *Experiment of 3 days*
- *Steady flow conditions*
- *Oblong bridge pier*

Main conclusions:

- *Both reconstructed the scour hole geometry with reliable detail and accuracy*
- *Promising approaches in bridge scour research field*



BENTO, A.M., COUTO, L., PÊGO, J.P. & VISEU T. (2018). ***Advanced characterization techniques of the scour hole around a bridge pier model****. In: River Flow: 9th International Conference on Fluvial Hydraulics, 5-8 September 2018, Lyon, France.*

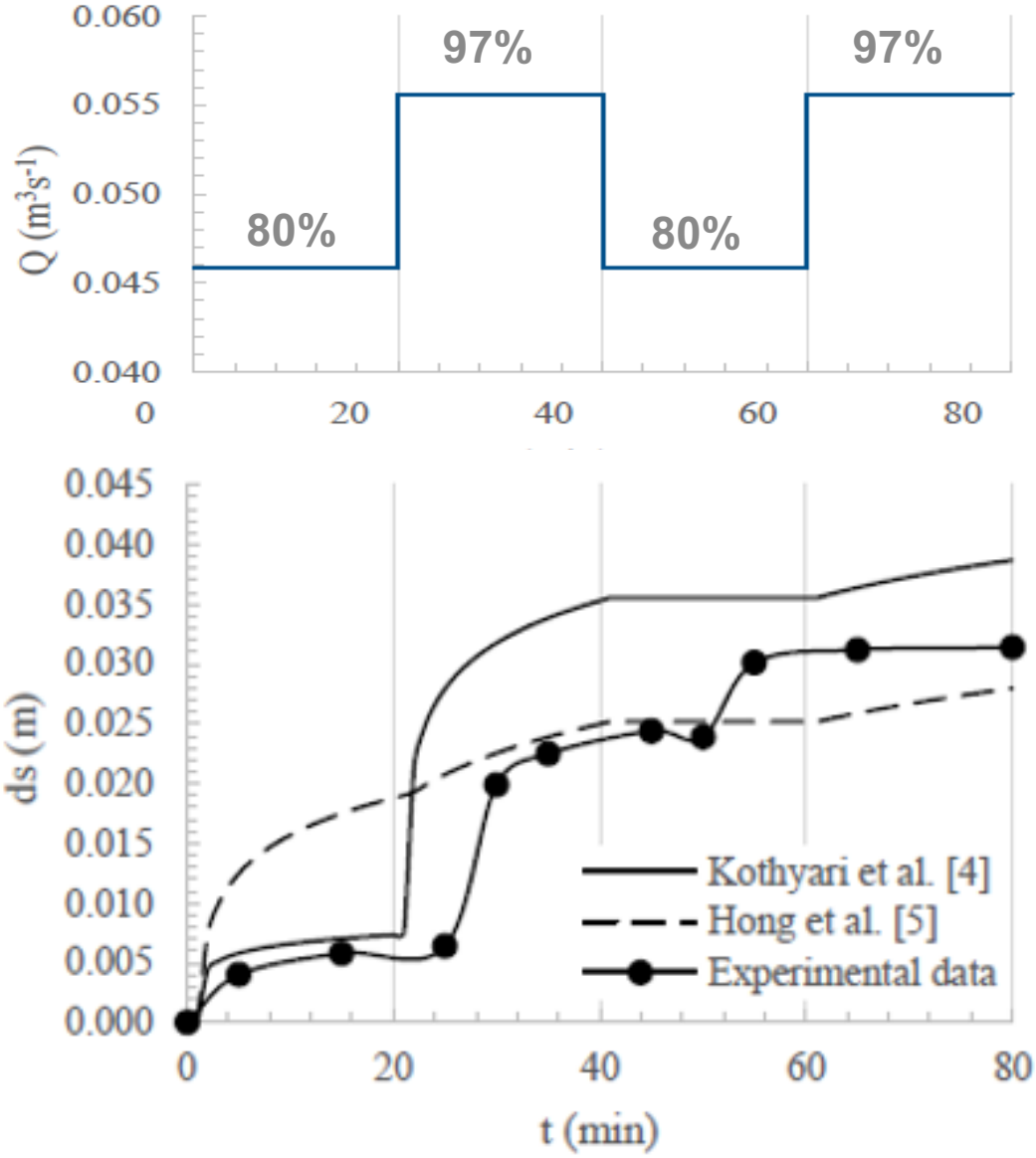
5th IAHR EUROPE CONGRESS
New challenges in hydraulic research and engineering
Trento12-14 June, 2018

Main features:

- *Experiment of 80 minutes*
- *Stepwise discharge hydrograph*
- *Circular bridge pier*

Main conclusions:

- *Scour depth increases significantly after a stepwise increase in discharge*
- *The experimental scour depths followed the trends of two empirical formulas*



BENTO, A.M., PÊGO, J.P., VISEU T. & COUTO, L. (2018). ***Evolution of local pier scour under flow conditions****. In: 5th Europe Congress, 12-14 June 2018, Trento, Italy.*

14: CONGRESSO DA ÁGUA

7, 8 e 9 Março 2018 • ÉVORA
Évora Hotel

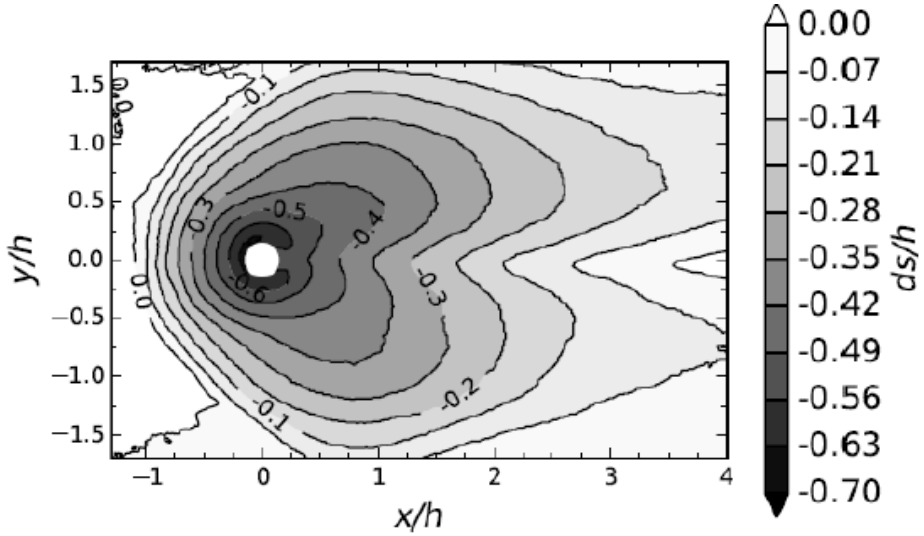
GESTÃO DOS RECURSOS HÍDRICOS:
NOVOS DESAFIOS

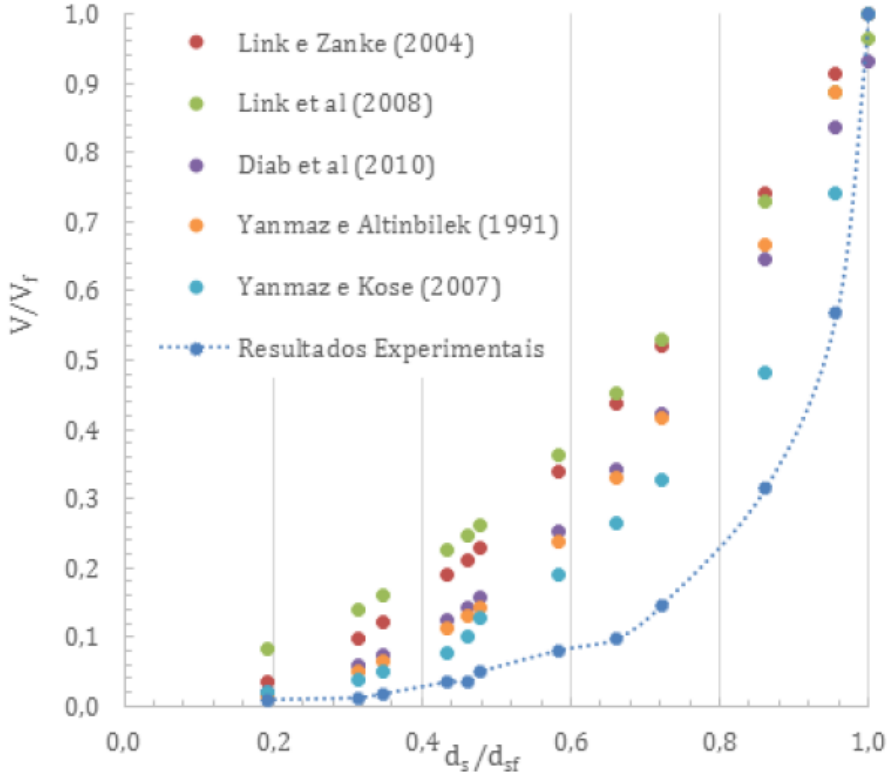
Main features:

- *Experiment of 7 days*
- *Steady flow conditions*
- *Circular bridge pier*

Main conclusions:

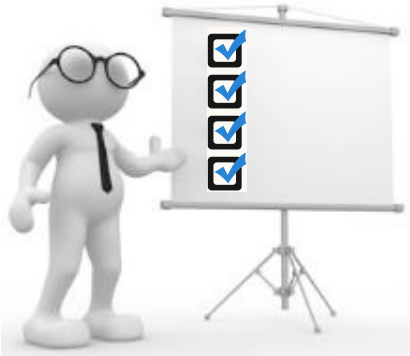
- *The pair of maximum scour depth and eroded volume values were compared with five empirical formulations for the experimental data*
- *The formulation that most approached the experimental results was the one of Yanmaz and Köse (2007).*





BENTO, A.M., VISEU T., COUTO, L. & PÊGO, J.P. (2018). ***Caracterização da Cavidade de Erosão em torno de Fundações de Pontes. Relação entre Volume Erodido e Profundidade de Erosão*** *(in portuguese). In: 14 Congresso da Água, 7-9 March 2018, Évora, Portugal.*

Work Done



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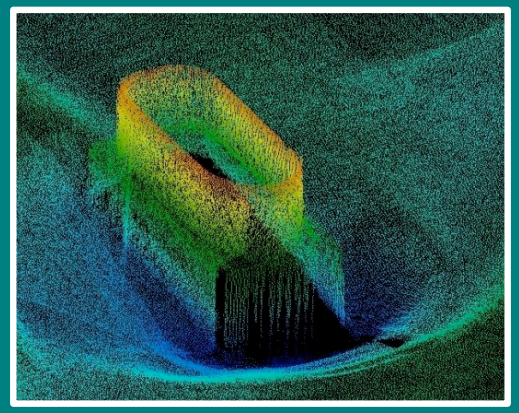
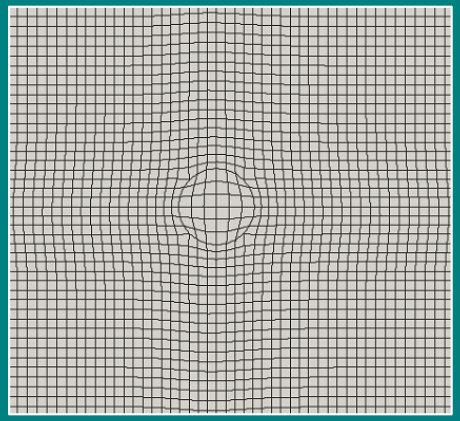


Selection of Portuguese bridges as case studies

Work in Progress

Acquisition **and adjustments** of the experimental **instrumentation and techniques**

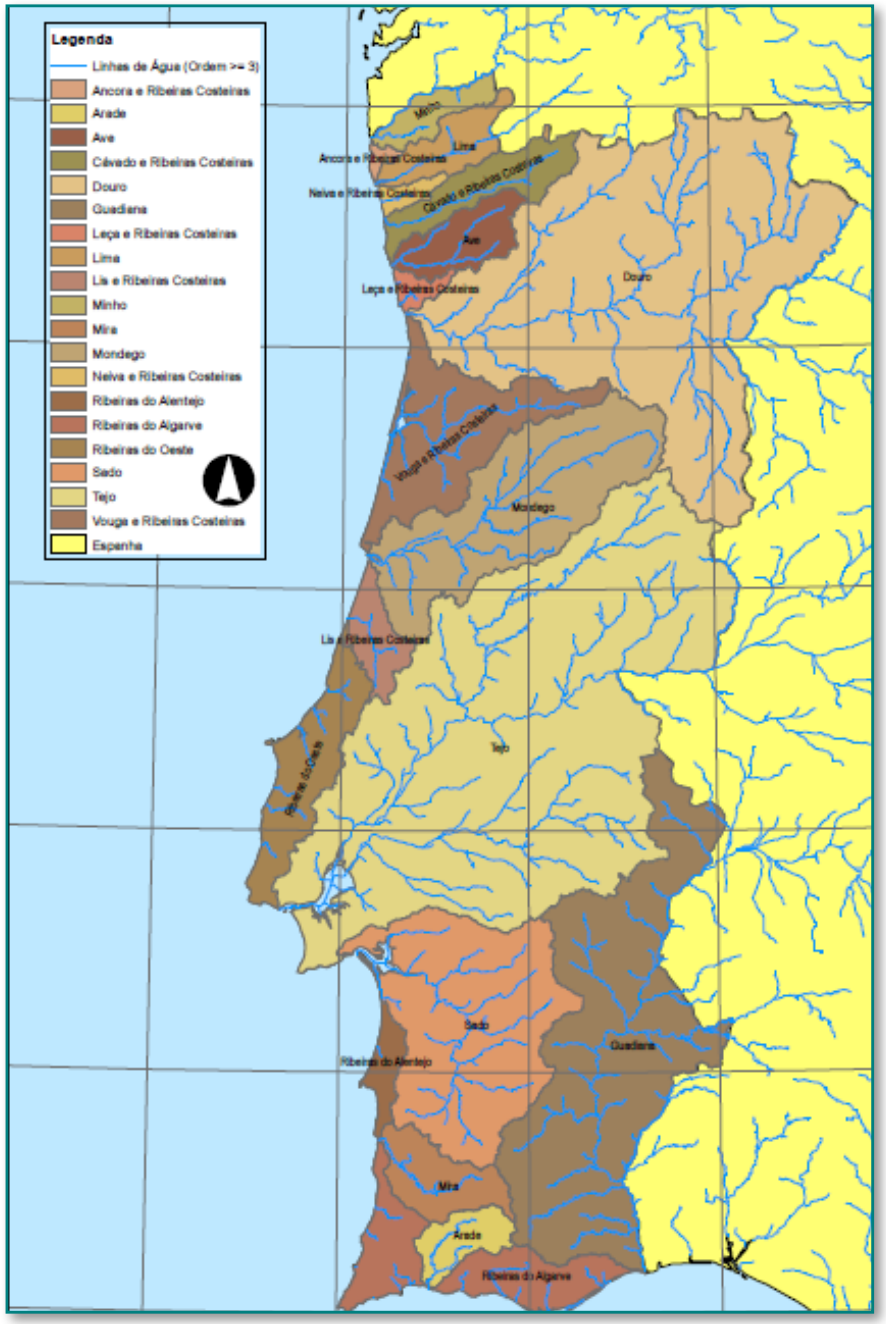
Creation of the numerical mesh for the tilting flume



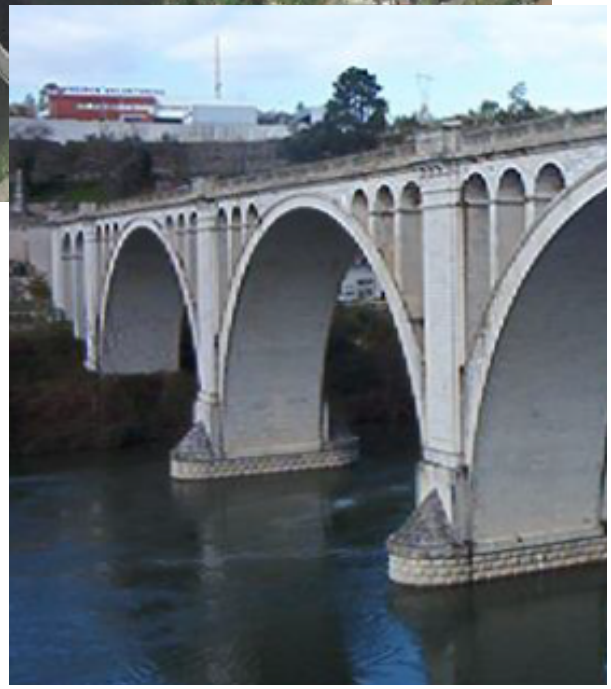
Compilation of field data

Definition of **the risk approach and methodology**

Statistical modelling of the hydrological and hydraulic variables

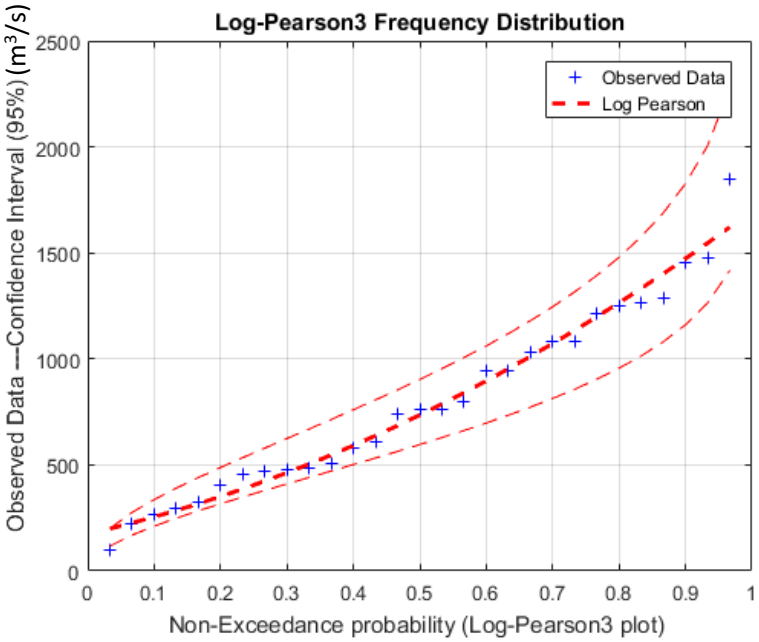


Portuguese watersheds, SNIRH

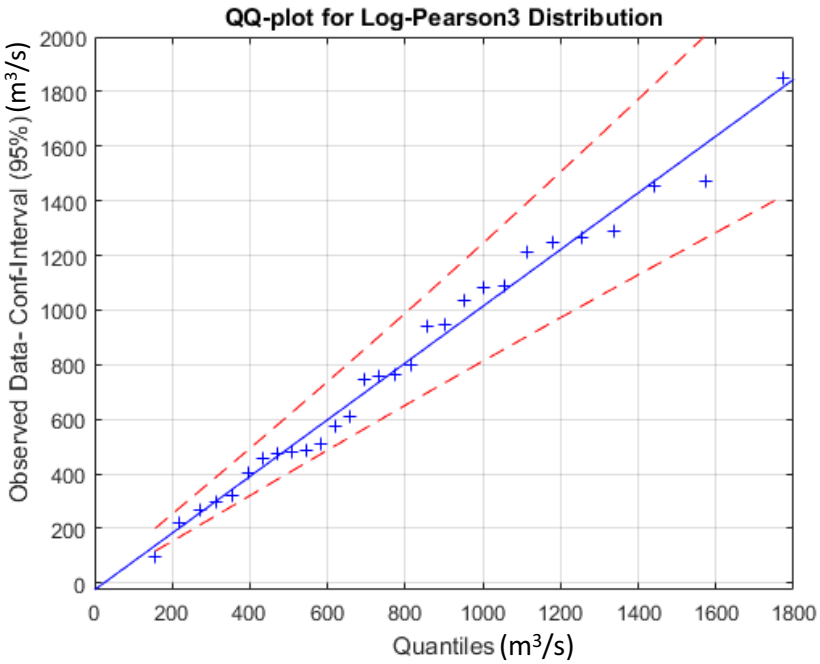


Duarte Pacheco bridge, Tamega River, Portugal

Statistical modelling of maximum annual discharges



Return Period (years)	Non-Exceedance Probability	Quantiles (m^3/s)
5	0.8	1180.0
10	0.9	1440.7
20	0.95	1659.9
50	0.98	1902.1
100	0.99	2056.7
500	0.998	2342.1
1000	0.999	2439.5
10000	0.9999	2680.7



Probability Plot position	C. Correlation (Observed/Quantiles)
Hazen Method	0.992
Weibull Method	**0.993**
Cunane Method	0.993
Chegodayev Method	0.993
Gringorten Method	0.993

Planned Work

Conduction of the experimental **campaign**

Collection and treatment of the experimental results

Simulation of the **flow field** at fixed **flat** and **scoured beds**

Simulation of the **scour patters** at **erodible beds**

Adaptation of the numerical tool(s) for a **Portuguese bridge**

Definition of the failure criterion(ia) to scour depth at bridge foundations

Derivation of empirical cumulative **distribution functions of exceedance of the failure** criterion(ia)

Evaluation of risk failure

Planned Work

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Conf: IAHR2019
Journ: Water/Sensors

Simulation of the **flow field** at fixed **flat** and **scoured beds**

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Conf: CNM2019
Journ: Water/JHR

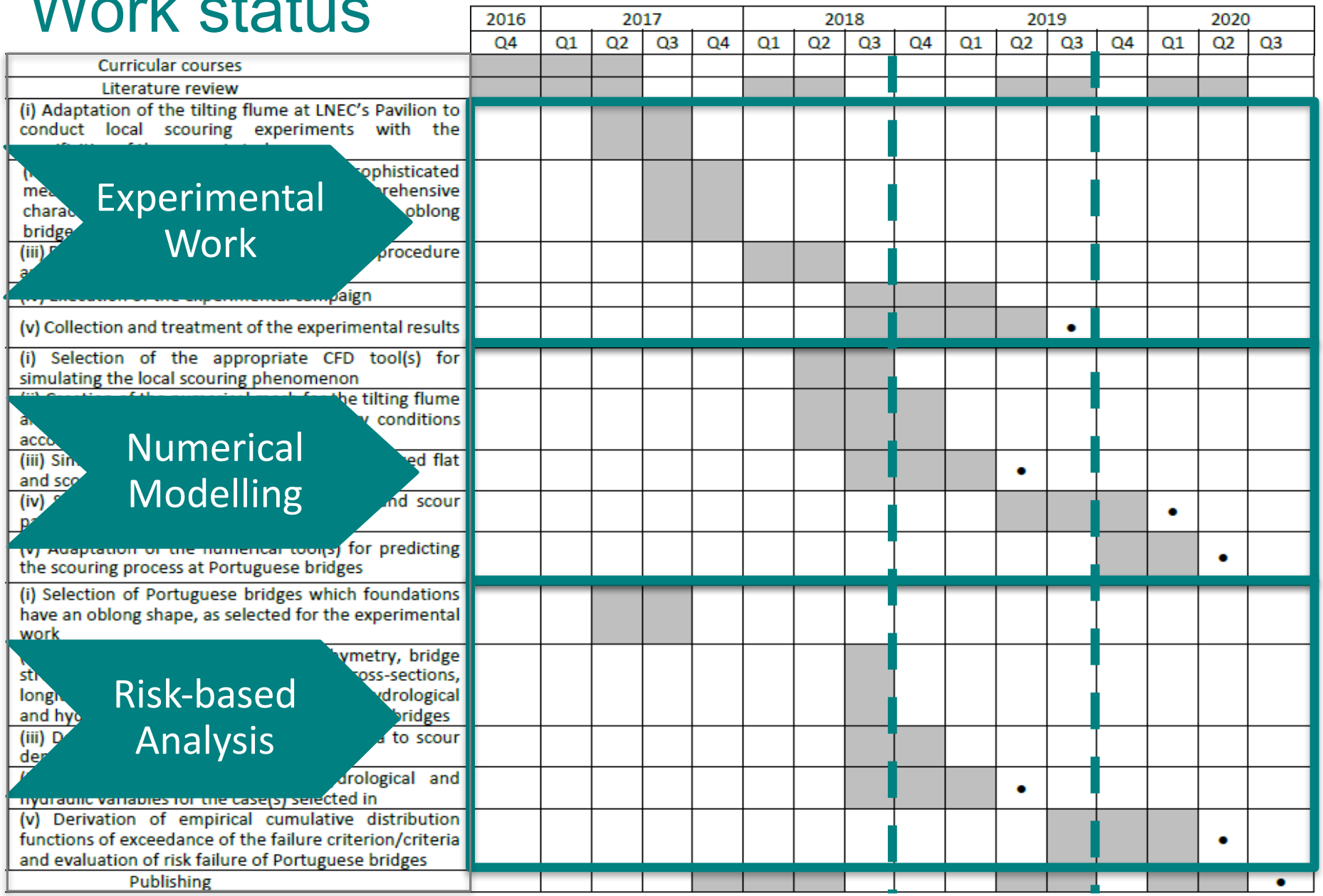
Definition of the failure criterion(ia) to scour depth at bridge foundations

Derivation of empirical cumulative **distribution functions of exceedance of the failure** criterion(ia)

Evaluation of risk failure

Conf: ICONHIC2019
Journ: Risk Analysis

Work status


2016
2017
2018
2019
2020
Q4
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Curricular courses
Literature review
(i) Adaptation of the tilting flume at LNEC's Pavilion to conduct local scouring experiments with the
Experimental Work
(v) Collection and treatment of the experimental results
(i) Selection of the appropriate CFD tool(s) for simulating the local scouring phenomenon
Numerical Modelling
the scouring process at Portuguese bridges
(i) Selection of Portuguese bridges which foundations have an oblong shape, as selected for the experimental work
Risk-based Analysis
(v) Derivation of empirical cumulative distribution functions of exceedance of the failure criterion/criteria and evaluation of risk failure of Portuguese bridges
Publishing

Thank you!

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