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

Third year workout

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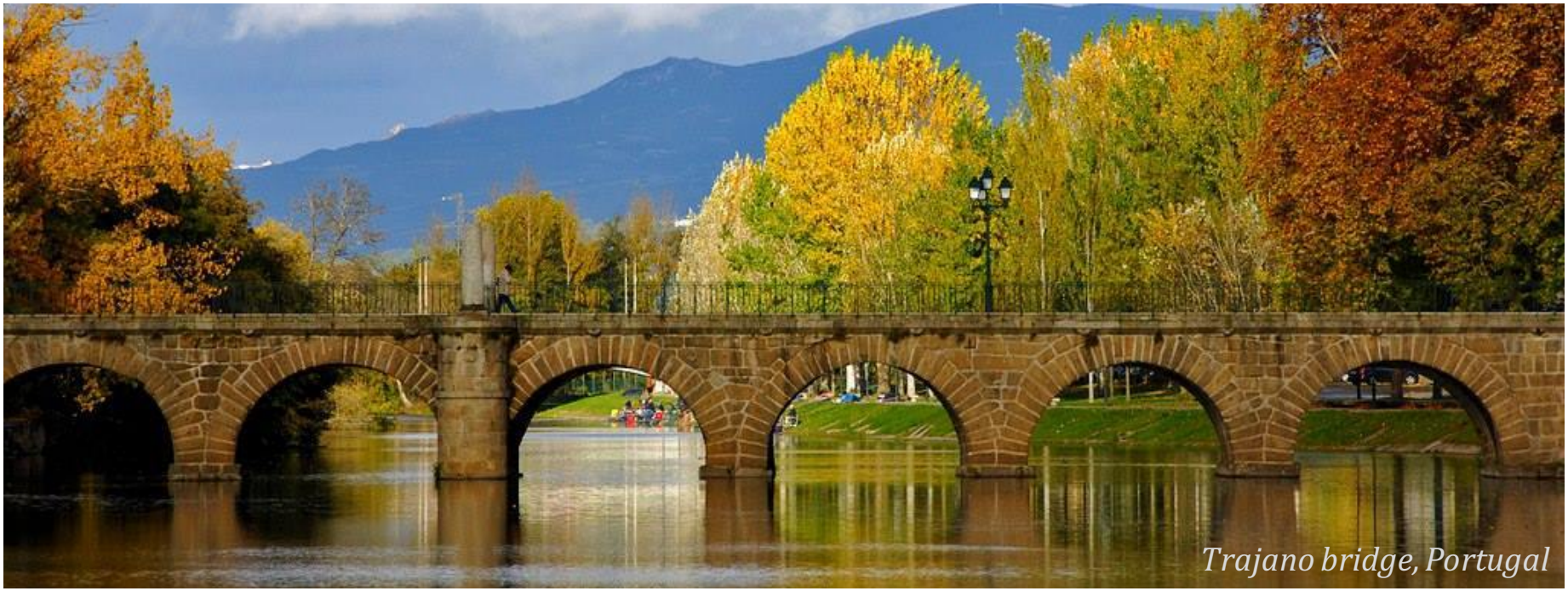


Trajano bridge, Portugal

Outline

- Introduction
- Objective and Approaches
- Work Done
- Work in Progress
- Planned Work
- Work Chronogram

Lezíria bridge, Portugal

Introduction

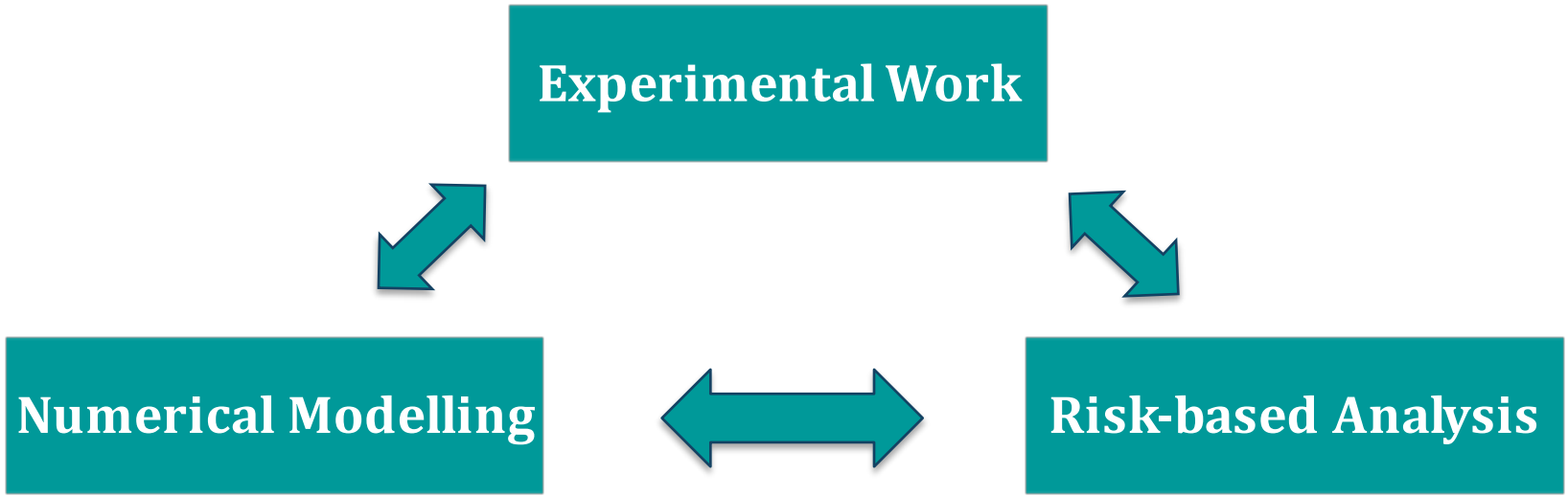
Bridge scour is widely recognized as a **major cause of bridge collapses**. Over a period of **30 years more than 1000 bridges** have **collapsed** in USA, **60%** of which as **result of scour at the bridge foundation level.**

Schoharie Creek bridge, NY, USA, 1987

Hintze Ribeiro bridge, Portugal, 2001

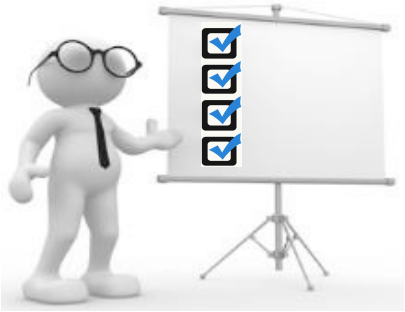
Objective and Approaches

Development of a **risk-based methodology** to estimate the **probability of failure** of bridge foundations under **clear water** and **live bed flow conditions**



Work Done

from the last workout ...



Experimental Work

Conduction of the first experimental run – **RUN 1**

Collection and treatment of the first experimental results

Numerical Modelling

Creation of the numerical mesh for the tilting flume and establishment of the initial boundary conditions according to experiments

Risk-based Analysis

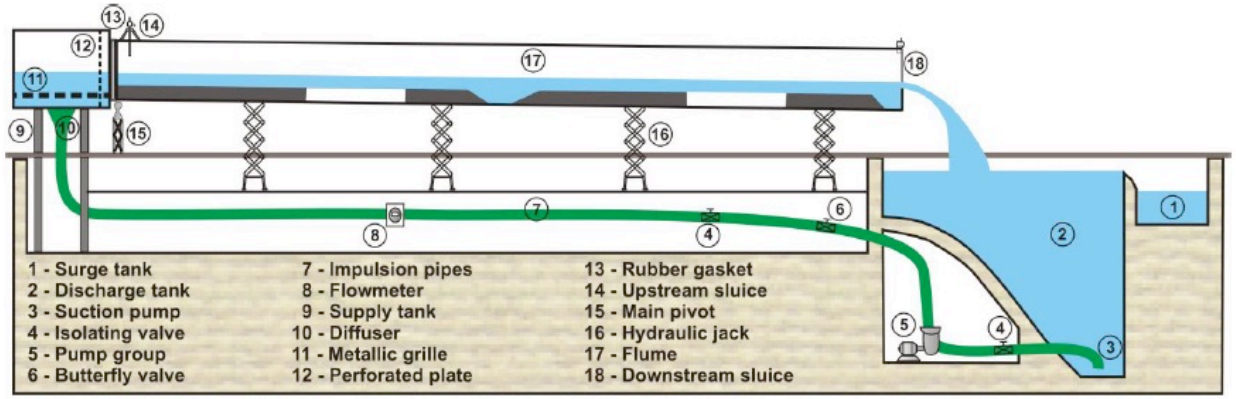
Compilation of field data

Definition of the risk approach and methodology

Statistical modelling of the hydrological and hydraulic variables

*Twelve **Experimental Runs** were defined*

CIV (LNEC): 40 m long, 2 m wide and 1 m deep



	$V/V_c = 0.95$			$V/V_c = 1.30$		
	h_1	h_2	h_3	h_1	h_2	h_3
Pier 11	*Exp. 1U*	*Exp. 2U*	-	*Exp. 4U*	*Exp. 5U*	-
Pier 14	*Exp. 1D*	-	*Exp. 3U*	*Exp. 4D*	-	*Exp. 6U*
Pier 17	-	*Exp. 2D*	*Exp. 3D*	-	*Exp. 5D*	*Exp. 6D*
Run	*Run 1*	*Run 2*	*Run 3*	*Run 4*	*Run 5*	*Run 6*

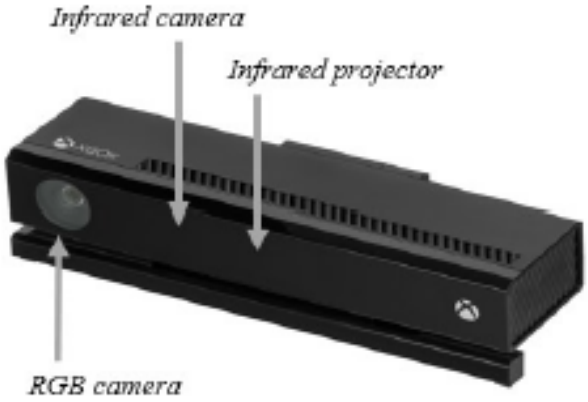
Upstream

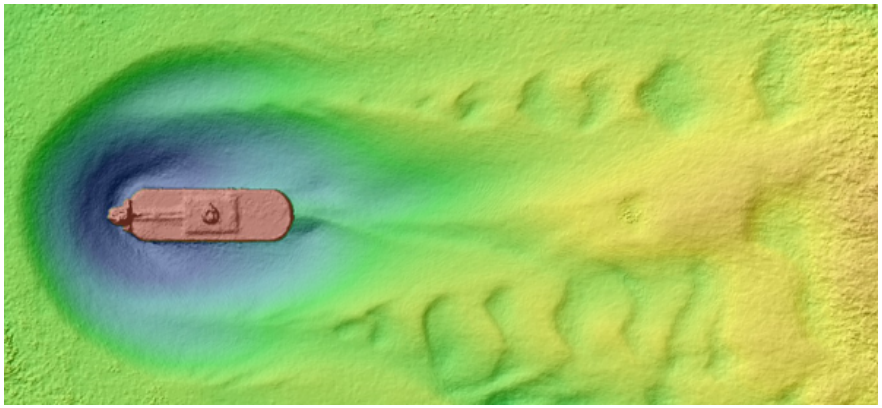
- Exp. 1U
- Exp. 1U_Fbed
- Exp. 1U_Ebed

Downstream

- Exp. 1D
- Exp. 1D_Fbed
- Exp. 1D_Ebed

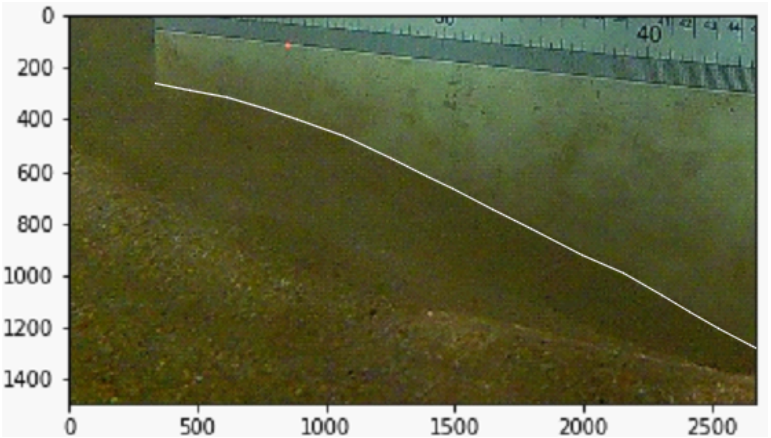
- Temporal evolution of d_s: **Hydrometers** at the pier fronts
- 3D: **Kinect V2 sensor** vs **Close-range photogrammetry**





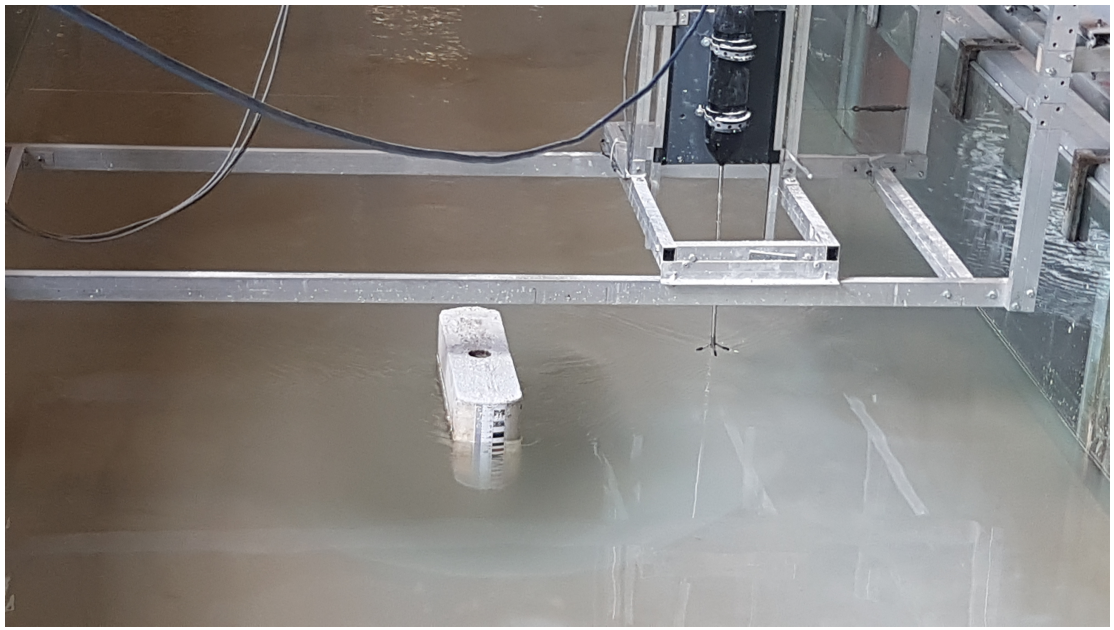
- **Underwater image processing**: during the scouring process

Action Cam
NK 3056 FHD



- **Flow discharge control:** electromagnetic flowmeter
- **Flow depth control:** acoustic and resistive probes, hydrometers along CIV, and rulers along the lateral glass windows
- **Instantaneous flow field** in two different moments:
  - at *fixed flat bed*
  - at a fixed eroded bed

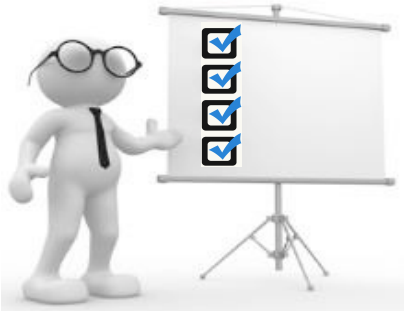
Downlooking vectrino



Moving carriage for Vectrino at CIV

Work Done

from the last workout ...



Experimental Work

Conduction of the first experimental runs – RUN 1 and RUN 4

Collection and treatment of the first experimental results – RUN 1

Numerical Modelling

Creation of algebraic and elliptical numerical meshes for the **experimental boundary conditions**

Afonso, Alexandre; Miranda, João; Araújo, José Daniel; Alves, Manuel; Silva Santos, Carlos; Rodrigues, Carlos; Ferrás, Luís; Nóbrega, Miguel; Resende, Pedro; Carvalho, Rita F.; Mould, Sacha; ***Bento, Ana Margarida****. "3rd Iberian Meeting of OpenFOAM® Technology Users". Porto: FEUP Edições, 2019. ISBN 978-972-752-258-3. 53 p*

Risk-based Analysis

Compilation of field data

Definition of the **risk approach and methodology**

Statistical modelling of the **hydrological** and **hydraulic variables**

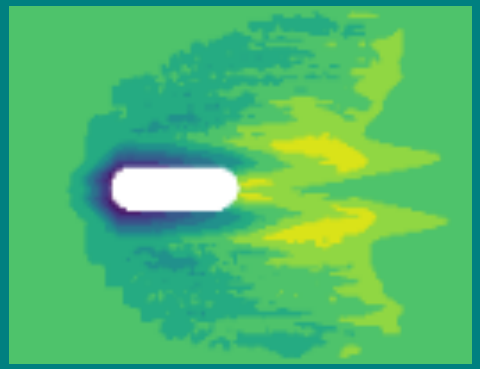
Work in Progress

Experimental Work

Conduction of RUN 4

Numerical Modelling

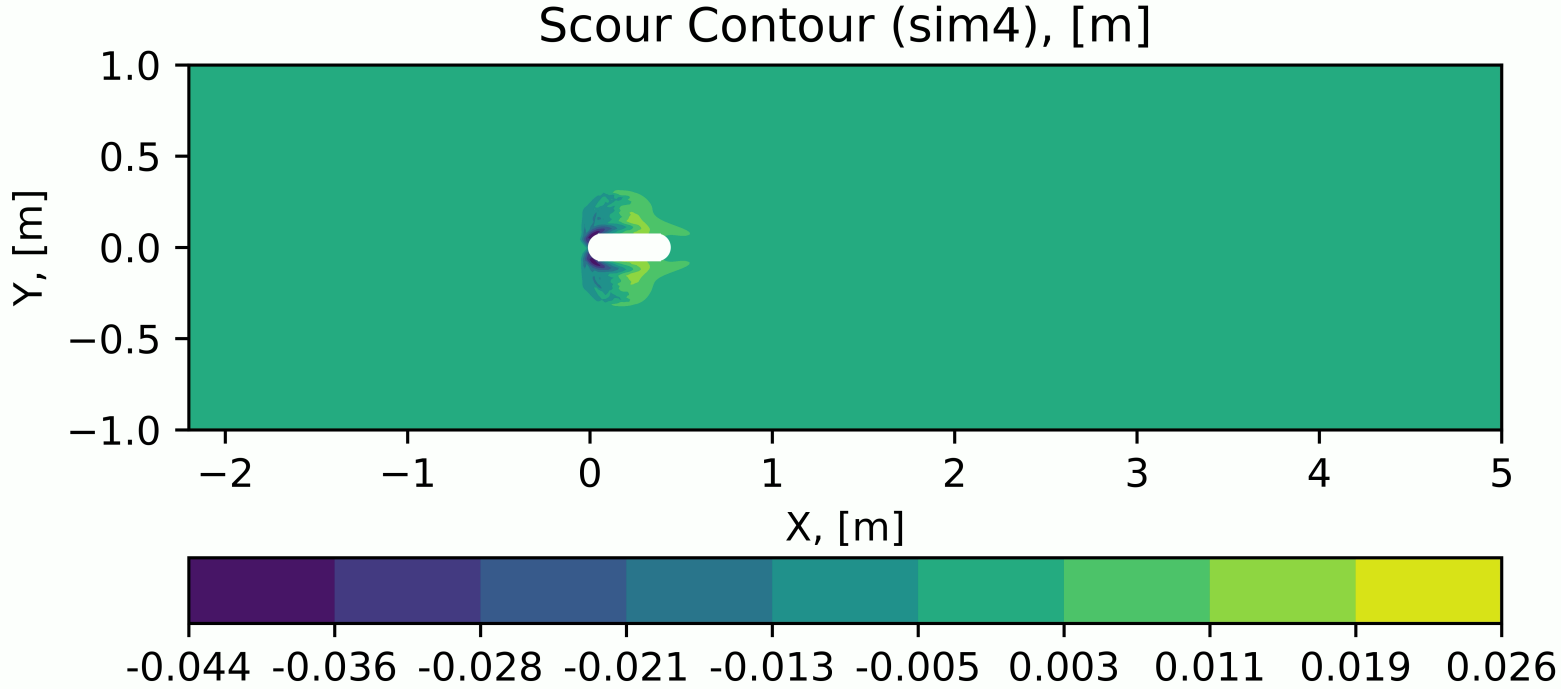
Simulation of the **turbulent flow field** and **scour patterns** at **erodible beds**



Risk-based Analysis

Statistical modelling of the hydrological and hydraulic variables

Generation of the Digital Terrain models, through topographic and batimetric measurements



	sim1	sim2	sim3	sim4
computational domain (m)	3.35 x 2.0		5.55 x 2.0	
bed shear stress	0.03047		0.0348	0.0355
bed roughness	0.0051			
turbulence model	k-epsilon			
time step (s)	5			
vertical cross-sections	21	19	19	19
1st bed cell height (%)	3.0	3.6		

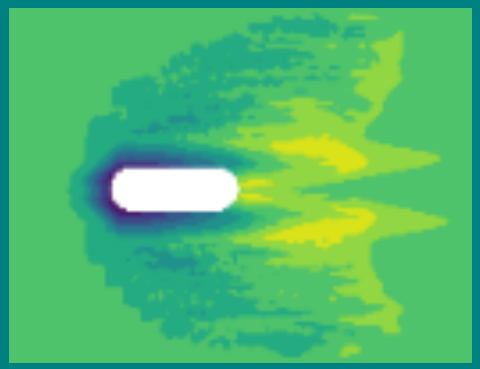
Work in Progress

Experimental Work

Conduction of RUN 4

Numerical Modelling

Simulation of the turbulent flow field and scour patterns at erodible beds

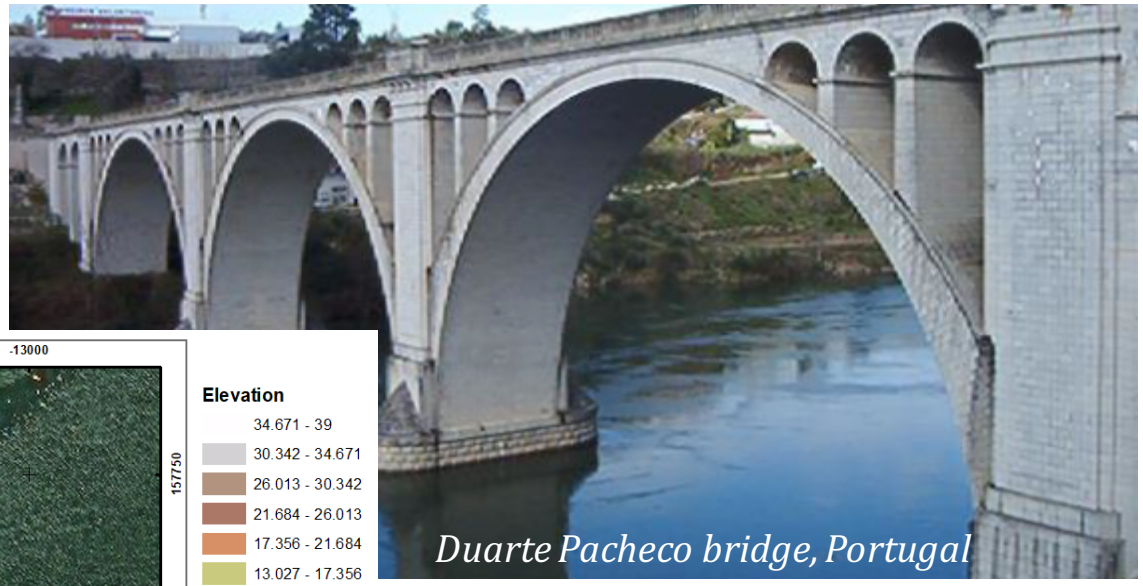


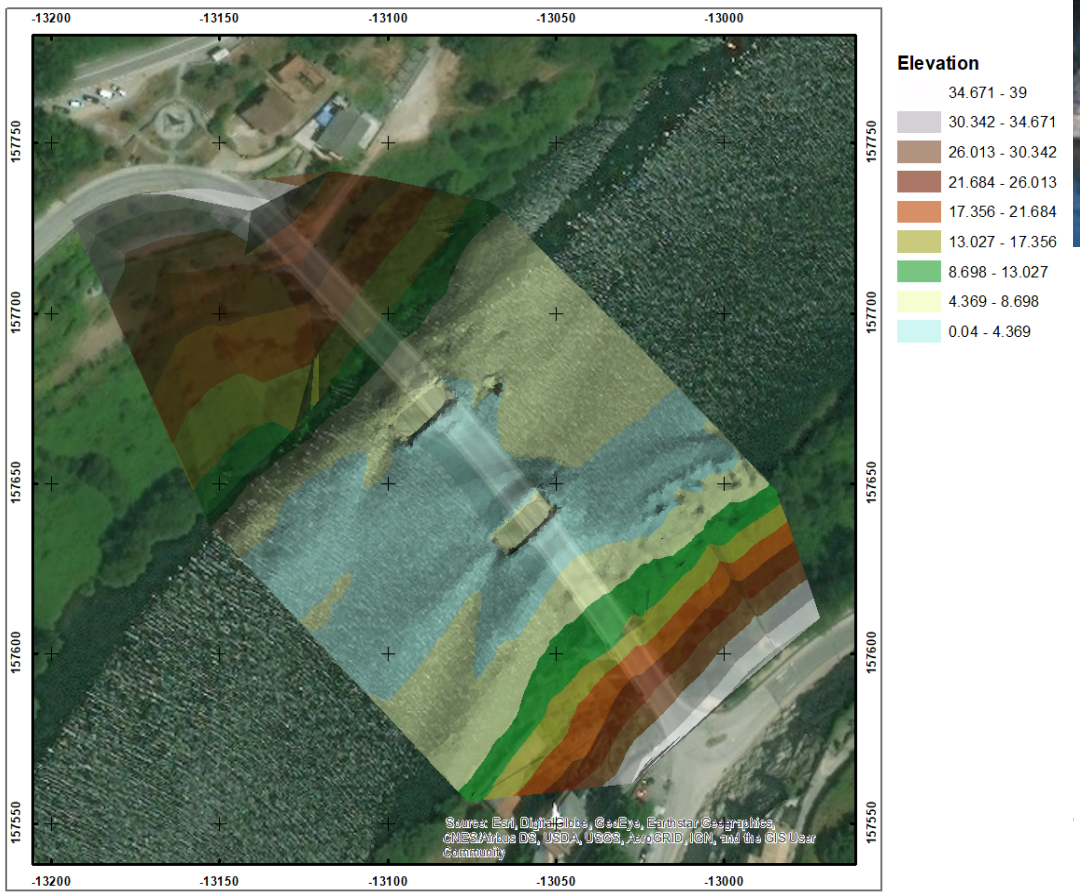
Risk-based Analysis

Statistical modelling of the hydrological and hydraulic variables

Generation of the Digital Terrain models (DTMs), by using **topographic and batimetric measurements** (Infraestruturas de Portugal)

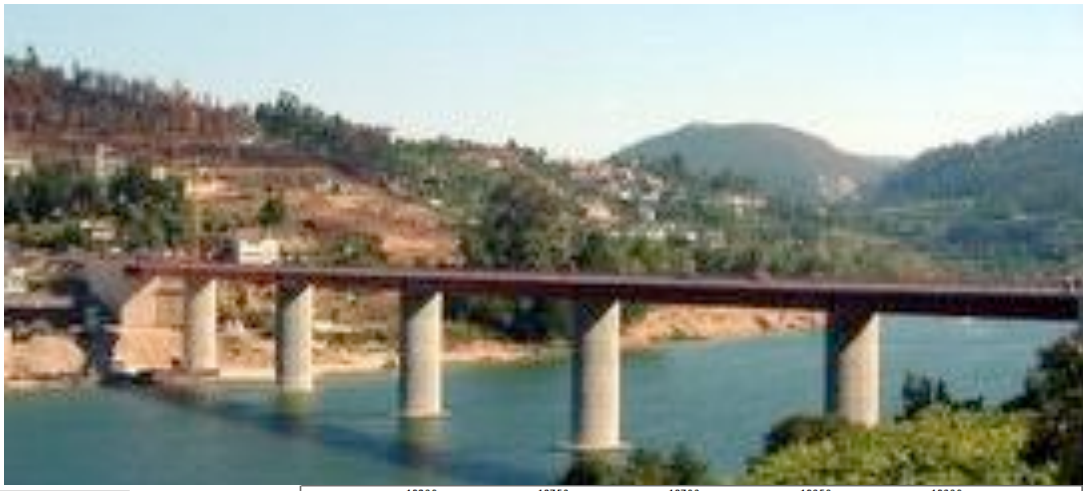
Duarte Pacheco bridge

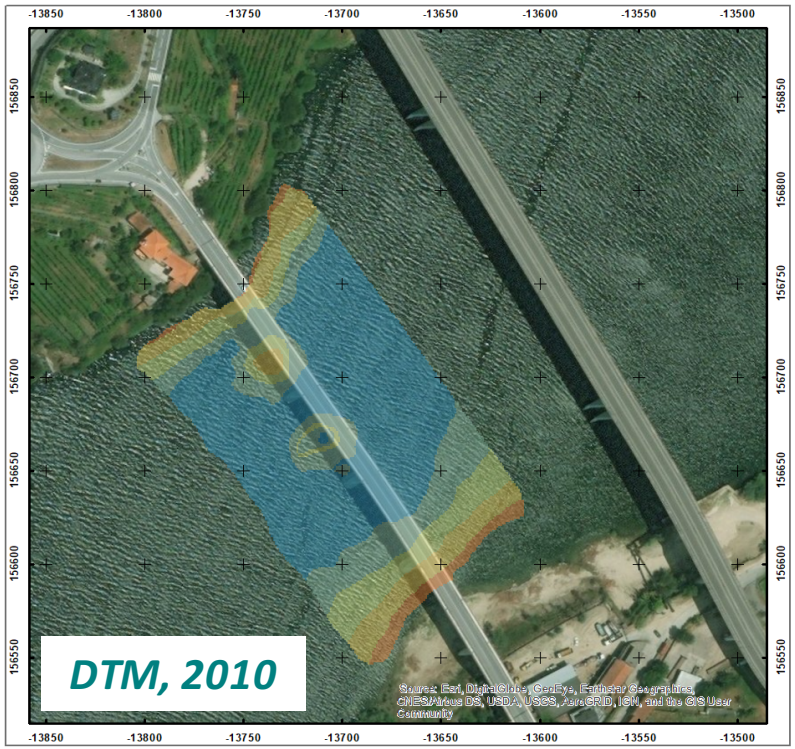


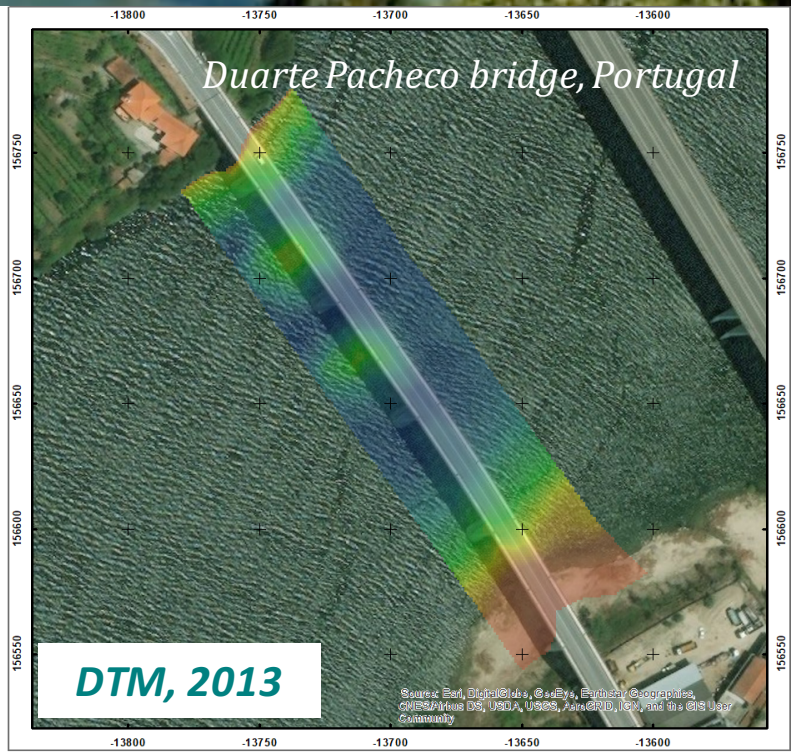


Digital Terrain Model, 2016

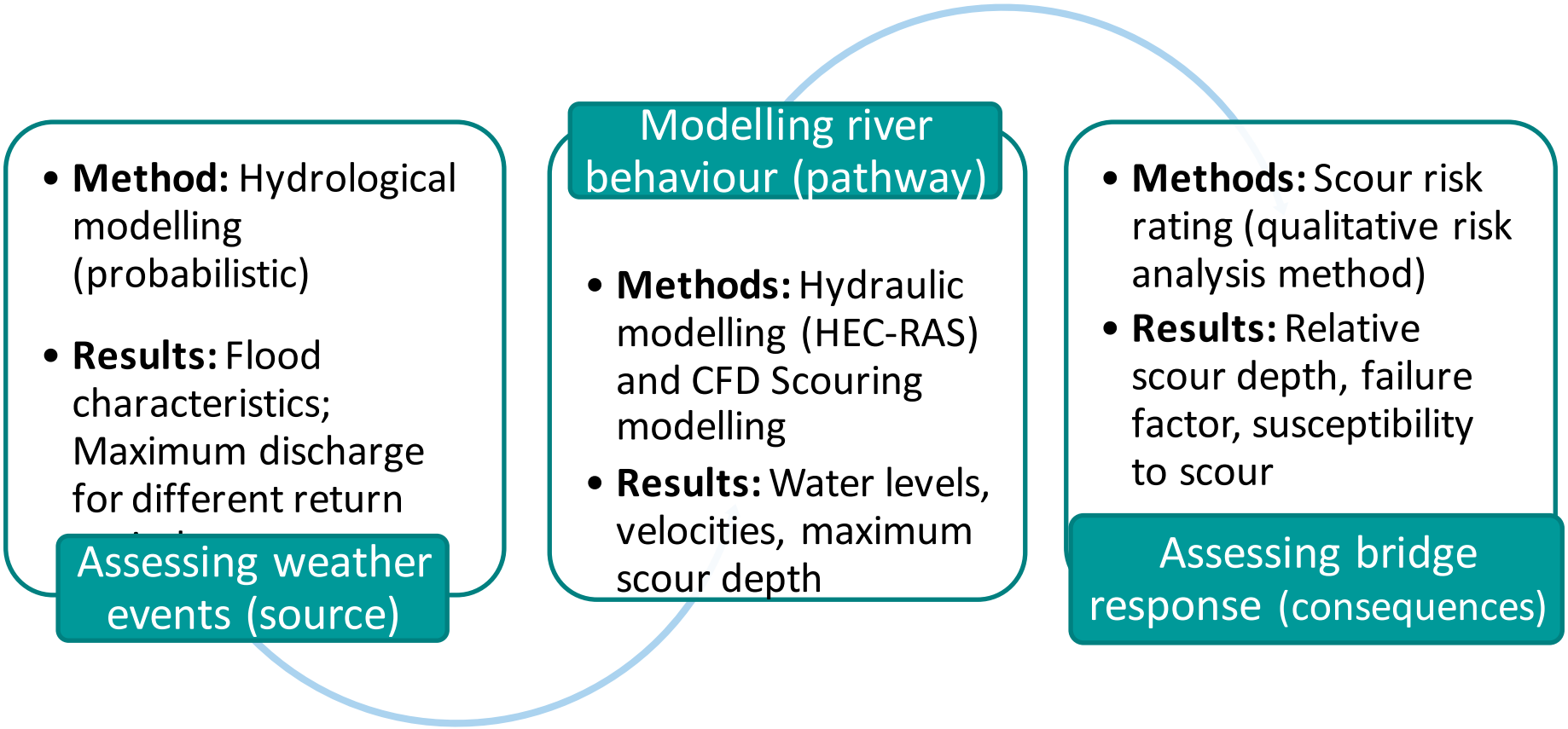
Hintze Ribeiro bridge







Approach for bridge scouring risk analysis



Bento, A.M., Viseu, T. Couto, L., Pêgo, J.P. Methodology for bridge scouring risk analysis (under development)

Planned Work

Experimental Work

Conclusion of the experimental campaign and data treatment

Publish a research paper with the experimental findings

Numerical Modelling

Conclusion of the numerical simulations prescribed for this PhD work

Submit/Publish a research paper with the numerical results

Risk-based Analysis

Application of the failure criteria to the already selected **Portuguese bridges**

Submit/Publish the risk-based analysis paper, applied to the case studies, under elaboration.

Work Chronogram

		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																	
Experimental work	(i) Adaptation of the tilting flume at LNEC's Pavilion to conduct local scouring experiments with the specificities of the present study																
	(ii)Conduction of trial runs, employing sophisticated measurement techniques for a comprehensive characterization of the scour hole around an oblong bridge pier model																
	(iii) Definition of the experimental campaign, procedure and measuring techniques																
	(iv) Execution of the experimental campaign																
	(v) Collection and treatment of the experimental results															October 2019	
Numerical Modelling	(i) Selection of the appropriate CFD tool(s) for simulating the local scouring phenomenon																
	(ii) Creation of the numerical mesh for the tilting flume and establishment of the initial boundary conditions according to experiments																
	(iii) Simulation of the turbulent flow field at fixed flat and eroded beds																
	(iv) Simulation of the turbulent flow field and scour patters at erodible beds																
	(v) Adaptation of the numerical tool(s) for predicting the scouring process at Portuguese bridges															February 2020	
Risk-based Analysis	(i) Selection of Portuguese bridges which foundations have an oblong shape, as selected for the experimental work																
	(ii) Compilation of information of bathymetry, bridge structural characteristics, channel cross-sections, longitudinal bed slopes, bed roughness, hydrological and hydraulic data of the selected Portuguese bridges																
	(iii) Statistical modelling of the hydrological and hydraulic variables for the selected Portuguese bridges																
	(iv) Definition of the failure criterion/criteria to scour depth at bridge foundations																
	(v) Derivation of empirical cumulative distribution functions of exceedance of the failure criterion/criteria and evaluation of risk failure of Portuguese bridges																July 2020
Publishing																	Aug 2020

Thank you very much!

Ana Margarida Bento

LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL

U.PORTO FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

Ponte de Lima, Portugal

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