QUALITY SPECIFICATIONS FOR ROADWAY BRIDGES,
STANDARDIZATION AT A EUROPEAN LEVEL

Scientific Report on
Short Term Scientific Mission

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Start Date	September 4, 2017	
End Date	October 13, 2017	
Reference Code	TU1406 - 38468	

ESF provides the COST Office through a European Commission contract

COST is supported by the EU Framework Programme

cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

CONTENTS

1. AIMS AND OBJECTIVES

This STSM aims to provide a valid quality control Bayesian network for a girder concrete roadway bridges, as most common ones in the road infrastructure. The target KPI is reliability. The ultimate aims of this short term scientific mission were:

- Contribute to the implementation of quality control plans in WG3, and also
- Contribute to the case studies within the WG4

2. WORK CARRIED OUT

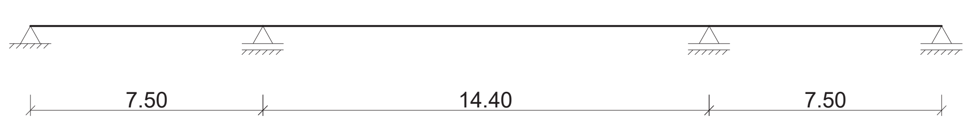
Having in mind that quality control framework should be universally applicable, due to a unique character of a bridge structure, we decided to create a Bayesian network for one specific roadway bridge. Accordingly, the most common type is chosen. The subject bridge is a three-span roadway overpass located in Portugal.

As about Bayesian network parameters, firstly the baseline state of the bridge has been determined. For this purpose, virgin state is considered. Assessment is based on the Portuguese design norms actual in the construction year. The idea was to make a relevant estimation of the structure resistance back in the time when it is built. Namely, the resistance of the structure cannot be lower than cutting forces corresponding to the load norm. This way, we are staying on the safe side, efficiently providing the resistance baseline value.

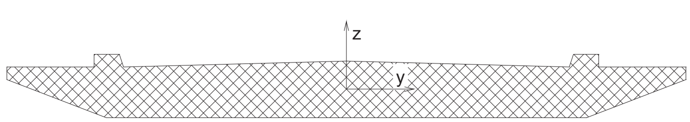
2.1. BRIEF SUMMARY OF THE SUBJECT BRIDGE

ID:	6240.0#0.0
Type of bridge:	Overpass
Construction year:	1983
Construction cost (€):	Non available
Type of structure:	Continuous span
Number of spans:	3
Total span (m):	29.4
Width (m):	8.2
Maximum span (m):	14.4
Design norms:	REBA (Regulamento de Estruturas de Betão Armado – 1967) and RSEP (Regulamento de Solicitações em Edifícios e Pontes – 1961).
Deck Materials:	Concrete B300.1 Steel A40 T (ribbed)

Structural system:



Girder cross section:

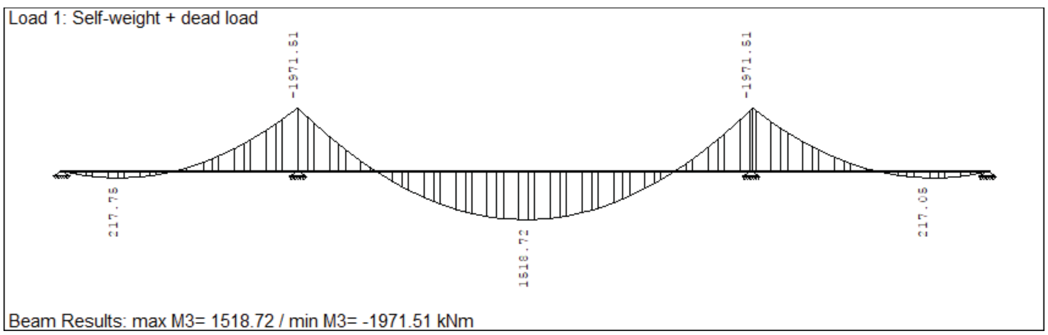


$A = 45876.50\ \text{cm}^2$
$I_y = 15357506.47\ \text{cm}^4$

2.2. LOAD ANALYSIS

2.2.1. PERMANENT LOAD

1	Self-weight	45876.5 · 10-4 · 25	=	114.70	kN/m
2	Asphalt cover	0.05 · 5.34 · 24.0	=	6.41	kN/m
3	Sidewalk	2 · (0.853 · 0.175 - 2 · (0.12 · π) / 4) · 20	=	5.22	kN/m
4	Cornice	2 · 0.0950 · 25	=	4.75	kN/m
5	Guard rail	2 · 1.0	=	2.00	kN/m
6	Safety rail	2 · 0.3	=	0.60	kN/m
7	Installations	2 · 0.5	=	1.00	kN/m
		∑	=	134.68	kN/m

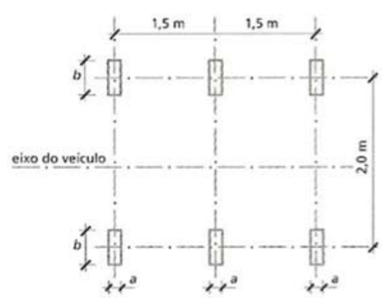


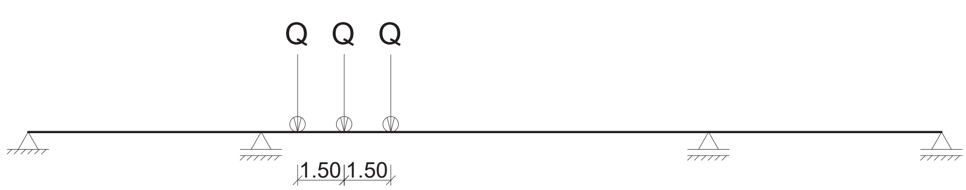
Note: all bending moment diagrams exported from Tower 7

2.2.2. TRAFFIC LOAD (RSEP, 1961) – DESIGN LOADS

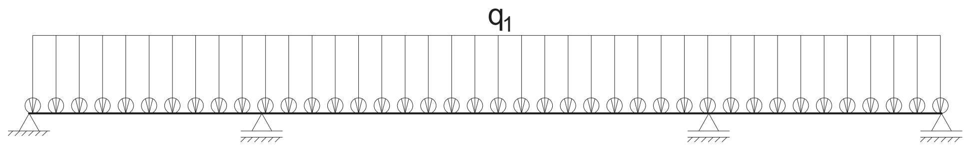
Traffic load, according to RSEP can be applied in two ways:

a) Vehicle type (VT)

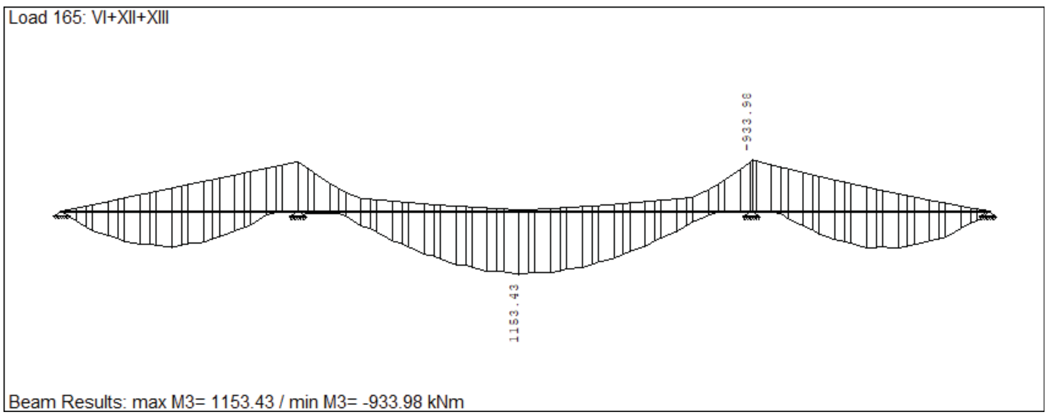




b) Distributed loads



Following values were applied:
Q = 200.0 kN
q1 = 3.0 kN/m2
q2 = 50.0 kN/m
Sidewalk distributed load = 3.0 kN/m2

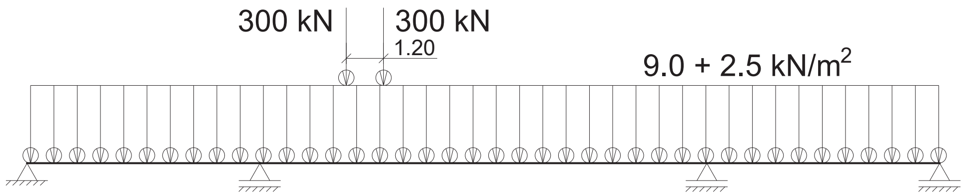


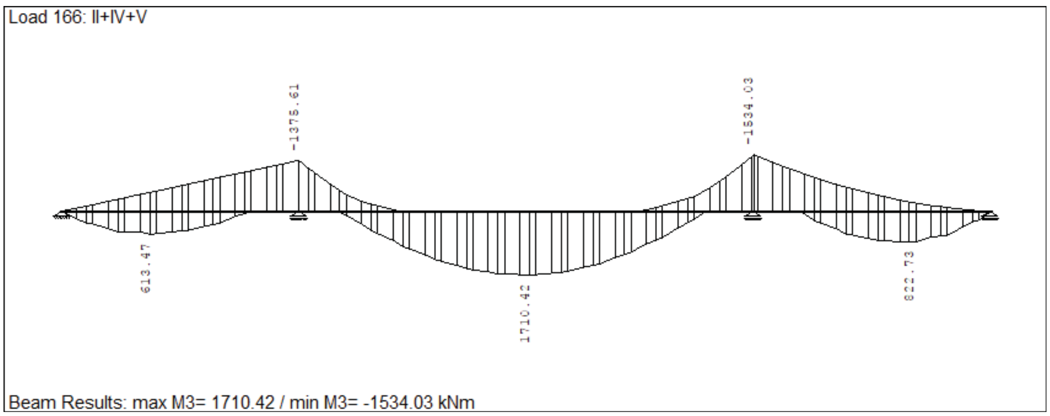
2.2.3.TRAFFIC LOAD (EN 1991-2 2003) – CURRENT LOADS

The width of notational lanes:
w = 5.39 m (<5.40 m)
↓
w_1 = 3.00 m
width of the remaining area: 2.39 m

Load model 1
UDL = $\alpha_{qi} \cdot q_{ki} = 1.0 \cdot 9.0 = 9.0$ kN/m^2
TS = $\alpha_{Qi} \cdot Q_{ki} = 1.0 \cdot 300.0 = 300.0$ kN

Sidewalk distributed load
= 2.5 kN/m^2





2.3. A PRIORI RELIABILITY

LIMIT STATE FUNCTIONS

Definition: g = Rc-sw-tr

Results from FORM analysis:
pf = 3.646e-007 beta = 4.95

Name	x_d	alpha
Rc	3724	-0.7337
sw	2226	0.2605
tr	1497	0.6275

BASIC VARIABLES

Name	Type	Parameters
Rc	LN	(6.475E+003,971.3)
sw	N	(1972,197.2)
tr	T1L	(600,180)

Note: Form analysis carried out by SaP software

2.4. NODES DEFINITIONS

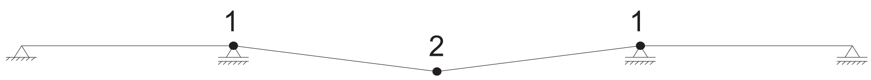
Transversal crack and Spalling are chosen as the most obvious KPIs easily obtained by visual inspection. Apart from these parameters, defect location is also taken into account considering possible plastic mechanisms. Certain vulnerable places on the structure are recognized as a potential plastic hinges. Those places are highly tensioned areas, labeled as “hot areas”.

With respect to the stated important parameters, the following nodes are established:

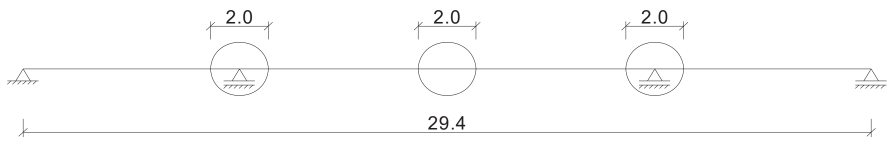
- Crack severity
- Crack location
- Spalling severity
- Spalling location

In the following, an estimated or calculated likelihoods of the corresponding events are given.

Possible plastic mechanism:



Hot areas:



Node definitions:

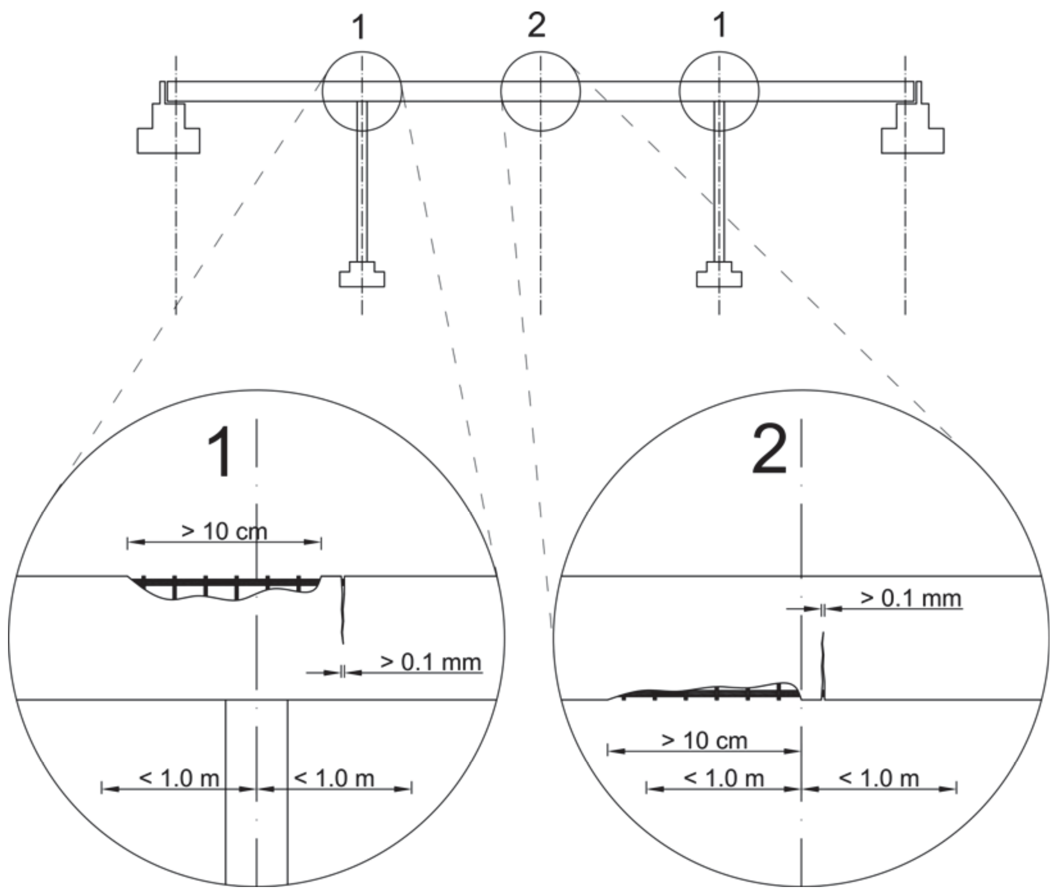
Node: Crack severity	
Stiffness reduction	Likelihood
5%	0.6
10%	0.2
15%	0.1
20%	0.1

Node: Crack location			
Location	Likelihood		
Outside hot area	= (29.4 - 2 - 2*2)/29.4	=	0.7959
Plastic hinge 1	= (2 + 2) / 29.4	=	0.1361
Plastic hinge 2	= 2 / 29.4	=	0.0680

Node: Spalling severity	
Section loss	Likelihood
5%	0.6
10%	0.2
15%	0.1
20%	0.1

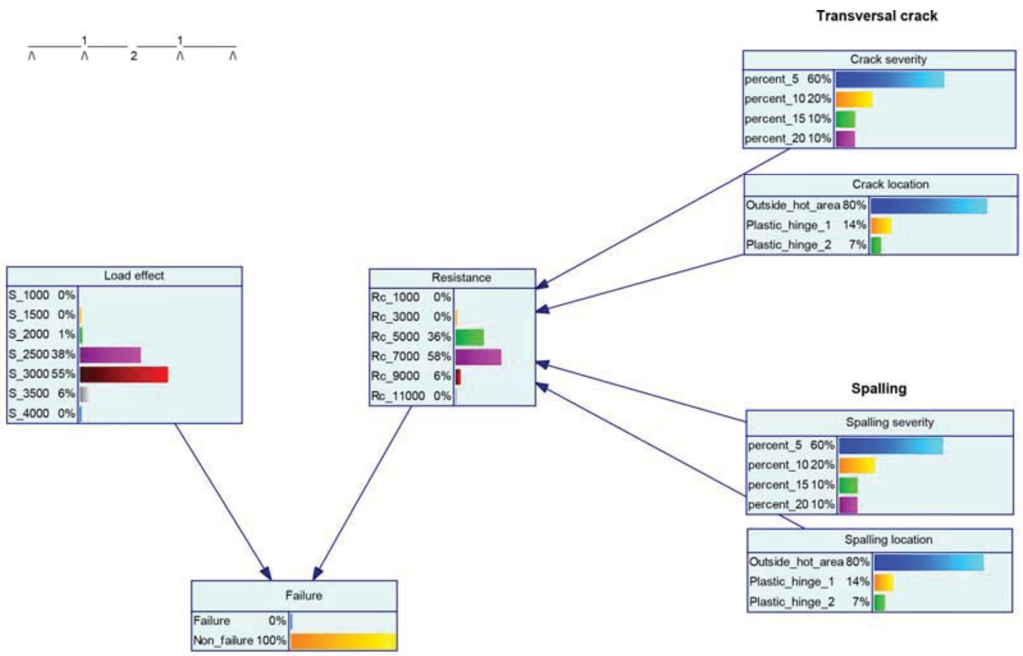
Node: Spalling location	
Location	Likelihood
Outside hot area	0.7959
Plastic hinge 1	0.1361
Plastic hinge 2	0.0680

Since the Crack severity and Spalling severity are rather qualitative characteristics of a defect, a proper assessment would be the inspector’s responsibility. Having said that, he or she should estimate the stiffness reduction of the cross-section caused by transversal crack, or the amount of section loss in case of concrete spalling. By doing this, his or her focus should be on the hot areas. In other words, the inspector should estimate the plastic moment reduction at the potential plastic hinge (illustrated in the following figure). According to plastic theory, by reducing the plastic moment in a certain hinge, an overall structure resistance is reduced. By considering every defect in each hot area, the resistance of the entire structure is updated.


1
2
1
1
> 10 cm
> 0.1 mm
< 1.0 m
< 1.0 m
2
> 0.1 mm
> 10 cm
< 1.0 m
< 1.0 m

3. MAIN RESULTS

The result of this STSM is a Bayesian network for a posteriori reliability analysis of the subject bridge (figure below).



4. FUTURE COLLABORATION

Future collaboration with professor Jose Matos and University of Minho could be continued through ERASMUS+ program. The subject of the future work should be development of BIM suitable for feeding Bayesian network.

5. FORESEEN PUBLICATIONS/ARTICLES

Everything done in this STSM is the subject of the proposed paper for IABSE conference, Nantes 2018.

6. ANNEXES

6.1. CONFIRMATION BY THE HOST INSTITUTION ON THE SUCESSFUL EXECUTION OF THE STSM

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V/ ref. N/ ref. Guimarães, 20 October 2017

Confirmation on the successful execution of a Short-Term Scientific Mission

to the Grant Holder of the COST Action TU1406: *Quality specifications for roadway bridges, standardization at a European level*

STSM Applicant (first name and last name): Dusan Isailovic

Home Institution: Faculty of Civil Engineering, University of Belgrade, Serbia

Host Institution: University of Minho, Portugal

I hereby inform that we welcomed Mr. Dusan Isailovic in our institution, in Guimarães from 4 September to 13 October 2017, with total duration of 40 days, within the framework of the TU1406 Short Short-Term Scientific Mission (STSM) programme.

The STSM was based on the current needs of the COST project and the work plan described by Mr. Dusan Isailovic in this STSM Application. The main goal of the STSM was to develop a Bayesian Network for the quality assessment of a common typology bridge.

Namely, during his stay he cooperate with the main objectives of COST TU 1406, especially with WG3, with a special emphasis to the Portuguese situation, namely, a direct involvement with Infraestruturas de Portugal on the identified Case Study. He also developed some research study regarding Bridge Information Modelling (BrIM) and Bayesian Networks.

During his STSM, he has performed all tasks that were set before him and will continue the work on the project goals after the finish of the STSM.

We are looking forward to future cooperation with Mr. Dusan Isailovic and his Home institution on the COST TU1406 project.

Yours sincerely.

First name and last name: José Matos

Signature: ______________________________

TU1406

COST ACTION

WWW.TU1406.EU