IM-SAFE WG1 Case Studies

Introduction

This is a form for case study collection and review within IM-SAFE WG 1.2. It follows the internal working document *Guide to Data Acquisition*.

Before submitting a form, please make sure the object is not already submitted by someone else by reviewing this list. Your contribution will be added automatically to the list when you submit the form.

The form consists of the following sections:
Section A - Description of the object
Section B - Description of the analysis
Section C - Description of the state of the object
Section D - References and pictures

If there is no suitable option, select *other* and specify. If the question is not applicable or you don't have the information, select *NA*.

At the end of each section A, B and C you are asked to write a text summarizing and extending the information given in that section. This is the text that will comprise the one-pager in the final deliverable. Please make sure the text is self-contained.

If you want to modify your answers you can navigate between the pages without loosing any information. When you have submitted the form, you will recieve a link by email that allows you to edit or delete your submission.
To submit several case studies, reuse the link you used to access this form.

If you have questions, please contact frida.liljefors@ntnu.no

Respondent's information

Name

Silvia de la Orden

Organisation

FERROVIAL

E-mail address

sorden@ci3.es

Section A - Description of the object

In section A the following information will be extracted:

- Basic information
- Structure type
- Network type
- Material
- Summary

Basic information

Name

Name of the object, e.g. *Söderström bridge*

Arcos de Alconétar Viaduct

Country

Give the name of the country in English.

Spain

Country code

Two-letter country code according to ISO 3166.

ES

Location

(City, area)

Cáceres (Extremadura)

Coordinates for the object

given in decimal degrees (DD), WGS84
E.g. coordinates for Trondheim: 63.4304900°, 10.3950600° (lat, long)

Latitude

E.g. 63.4304900 for Trondheim

39,719278

Longitude

E.g. 10.3950600 for Trondheim

-6,410628

Year of construction

2006

Structure Type

Type of structure

Bridge

Network type

Type of traffic network

Specify the main useage of the structure

Road

Material information

Material

Select all structural materials that are relevant for the assessment.
Further options will be given when selecting concrete or timber.
For composite structures, select *composite* and the comprised *materials.* E.g. for a concrete steel composite structure, select *concrete, steel, composite*.

Concrete

Steel

Composite

Type of concrete

For concrete, select the type(s) of concrete.

Reinforced

Type of composite

For composite material, select the type(s).

Not answered

Summary section A

Summary A

Write approx. 700 characters text describing the structure. The text should contain the main information of this section A, and provide further details.

The bridge over the Tajo river at Alcántara reservoir is formed by two twin 400 m long structures, each of which is an arch bridge 220 m span and 42.50 m rise. Each of the arches is formed by two box sections braced to each other.

The deck lays on a set of columns uniformly spaced over the whole length of the bridge (every 26 m). The columns are concrete in the approach spans and steel over the arches, rigidly connected to them.

Each deck is a continuous composite steel-concrete structure (twin box girders) simply supported on the columns.

Section B - Description of the analysis

In section B the following information will be extracted:

Case type

Verification type and scale

Initiation of the assessment

Structural analysis

Information updating

Intervention

Summary

Case type

Specify whether the main driver of the case study is to produce original research content (research) or to support real, practical decisions (consulting).

Other

Other case type

If other, please specify.

Research & Consulting

Initiation of assessment

NB. Assessment can include monitoring.

Pure research interest

Other

Other initiation of assessment

If other, please specify.

Verification of the correct structural behavior due to the vibration problem detected during construction

Predominant verification type

Choose from:

Risk-based (due account of consequences and event probabilities, explicit representation of uncertainties)

Reliability based (due account of event probabilities and assessment of reliability criteria, explicit representation of uncertainties)

Design value criteria (structural capacity and demand expressed as design values, implicit representation of uncertainties)

Qualitative criteria (e.g. damage classes, consequence classes, ranking based on indicators, etc.)

Engineering judgement

Other

Engineering judgement

Predominant verification scale

What is the spatial boundary of the analysis?

Other

Other verification scale

If other, please specify.

Structural Component & Structural System

Structural analysis

Structural analysis/Type of limit state

Ultimate limit state

Fatigue limit state

Serviceability limit state

Information updating

The structural performance is described by a limit state (LSF)/design equations (DE) that contains variables representing relevant properties related to resistance, stiffness, dimensions, loads, etc. The information from inspection or monitoring is somehow utilized in the LSF/DE, but how?
Direct information means that a relevant property contained in the LSF/DE is directly measured. If only an indicator for the relevant property is measured, it is referred to as **indirect** information. Then a model is necessary to connect the information to the relevant property (in COST TU1406 this is called "Performance Model").
Bayesian methods combine prior information and new data from inspection/monitoring into posterior information. **Non-bayesian** methods refers to classical statistical methods where only the new data is evaluated.

Indirect non-bayesian

Physical intervention

Here, all physical interventions that have been considered as possible options should be selected.

Other

Other physical intervention

If other, please specify.

Physical intervention (strengthening/Upgrading) will only be considered if the structural behavior during working life is found to be not suitable.

Operational intervention

Here, all operational interventions that have been considered as possible options should be selected.

Maintenance

Monitoring

Summary B

Write approx. 700 characters text describing the analysis. The text should contain the main information of this section B (structural, probabilistic and decision analysis), and provide further details.

During construction, the action of the wind, triggered a resonant response in the structure in January 2006 (vortex shedding). The structure was just the freestanding arch (the columns had not yet been assembled).

The phenomenon produced considerable damage at intermediate sections of the arch. The movement was an antimetric vibration of the arch in its plane with a frequency of 0,70Hz (second mode).

A dynamic data acquisition system was installed and more than 2.600 wind events were recorded between the February and June 2006. Aerodynamic deflectors were installed (see picture below). They proved to be very effective in suppressing or reducing the formation of vortexes.

However, It was decided to keep the dynamic monitoring system with the bridge open to traffic to survey the structural behavior under the wind action. The opportunity was taken to obtain information regarding joint movements and other environmental actions.

Total amount of sensors is 54 (thermometers, anemometers-vanes, accelerometers and lasers for joint displacements).

Section C - Description of the state of the object

In section C the following information will be extracted:

Deterioration process

Damage

Investigation

Summary

Deterioration process

Specify all relevant deterioration processes.

Concrete deterioration process

NA

Steel deterioration process

NA

Damage

Specify all relevant damage.

General damage

NA

Concrete damage

NA

Steel damage

Cracks

Investigation

Prior information

Select all prior information that was (available, used, specified...?)

Design standard

Drawings

Design documents

Previous inspections

Monitoring

Numerical model

Performance indicator

Select all physical parameters measured/monitored (performance indicators).

Displacement

Dynamic response (acceleration, damping, frequencies)

Other actions (wind, temperature, earthquake...)

Inspection/monitoring method

Select all inspection/measuring/monitoring methods used in the case study.

Other

Other inspection/monitoring method

If other method, please specify.

Electronic sensors with static/dynamic data acquisition system, real-time transmission system and cloud web platform.

Summary C

Write approx. 700 characters text describing the state of the structure. The text should contain the main information of this section C (deterioration process, damage, inspection/monitoring method), and provide further details.

The maximum vibration recorded since the deflectors were installed is 0.060g (± 37mm amplitude), caused by an average wind speed of 29km/h and associated with a frequency of 0.64Hz. That movement is 20 times less than that estimated in the structure before the installation of the deflectors.

Section D - References and pictures

All cases studies are documented in publicly available documents.
If the document is open access you can upload it as a pdf file.

Documents
Give 1-3 references for the case study.
For each document, write the reference in Harvard referencing style. If open access, upload the document.

Number of references
How many documents do you want to make reference to?

Not answered

Pictures
Upload in total 1-5 pictures that illustrate (if available):

Section A. Description of the structure.

Section B. Analysis.

Section C. State of the structure (deterioration process, damage, inspection/monitoring method.)
For each picture, confirm that we have the right to publish it, give reference when applicable and write a caption.

Number of pictures
How many pictures do you want to upload?

5

Image file 1
Name the file Name_1.jpg (or any other image format)
e.g. Soderstrom_bridge_1.jpg

SectionA.png

(1236778 bytes)

Picture caption 1

Arcos de Alconétar Viaduct

Section 1
To which section does the picture belong?

A

Copywrite 1
Do we have the right to publish the picture?

Yes

Image reference 1

Not answered

Image file 2
Name the file Name_2.jpg (or any other image format)
e.g. Soderstrom_bridge_2.jpg

SectionA_1.jpg

(57259 bytes)

Picture caption 2

Arcos de Alconétar Viaduct Scheme

Section 2
To which section does the picture belong?

A

Copywrite 2
Do we have the right to publish the picture?

Yes

Image reference 2

Not answered

Image file 3
Name the file Name_3.jpg (or any other image format)
e.g. Soderstrom_bridge_3.jpg

SectionB.jpg

(248949 bytes)

Picture caption 3

Aerodynamics deflectors to avoid resonance

Section 3
To which section does the picture belong?

B

Copywrite 3
Do we have the right to publish the picture?

Yes

Image reference 3

Not answered

Image file 4
Name the file Name_4.jpg (or any other image format)
e.g. Soderstrom_bridge_4.jpg

SectionC_1.JPG

(39790 bytes)

Picture caption 4

Figure 1: Data acquisition system located inside the arch

Figure 2: Arch accelerogram and frequency spectrum

Section 4
To which section does the picture belong?

C

Copywrite 4
Do we have the right to publish the picture?

Yes

Image reference 4

Not answered

Image file 5

Name the file Name_5.jpg (or any other image format)
e.g. Soderstrom_bridge_5.jpg

SectionC_2.JPG

(55932 bytes)

Picture caption 5

Figure 1: Wind speed and direction polar diagram

Figure 2: Classification histogram of wind direction

Figure 3: Vertical acceleration in north intermediate section (red), Vertical acceleration in south intermediate section (blue) and transverse horizontal acceleration in the center or the arch (green)

Section 5

To which section does the picture belong?

C

Copywrite 5

Do we have the right to publish the picture?

Yes

Image reference 5

Not answered

Comments for development

Give feedback on the scheme (optional).

Not answered