EGU 2020 – 10663 – GI 5.2

Online | 4–8 May 2020

An integrated geophysical approach for structural behavior characterization of the Gravina bridge (Matera, Southern Italy)

Vincenzo Serlenga(1), M. R. Gallipoli(1), R. Ditommaso(2), N. Tragni(1), T.A. Stabile(1), A. Perrone(1), D. Pietrapertosa(3), R. F. Carso(3)

(1)National Research Council of Italy, Institute of Methodologies for Environmental Analysis, Tito Scalo (PZ), Italy
(2) SISIA S. r. l., Venosa, Italy
(3) ANAS Spa, Area compartimentale Basilicata, Potenza, Italy

Contact details: vincenzo.serlenga@imaa.cnr.it

From slide 2 to slide 5 a short presentation can be found

From slide 7 onwards the full presentation can be found

MOTIVATION OF THE STUDY

- Civil infrastructures are crucial parts of the road asset and their possible degradation, with related consequences, may have great social, economical and safety impacts;

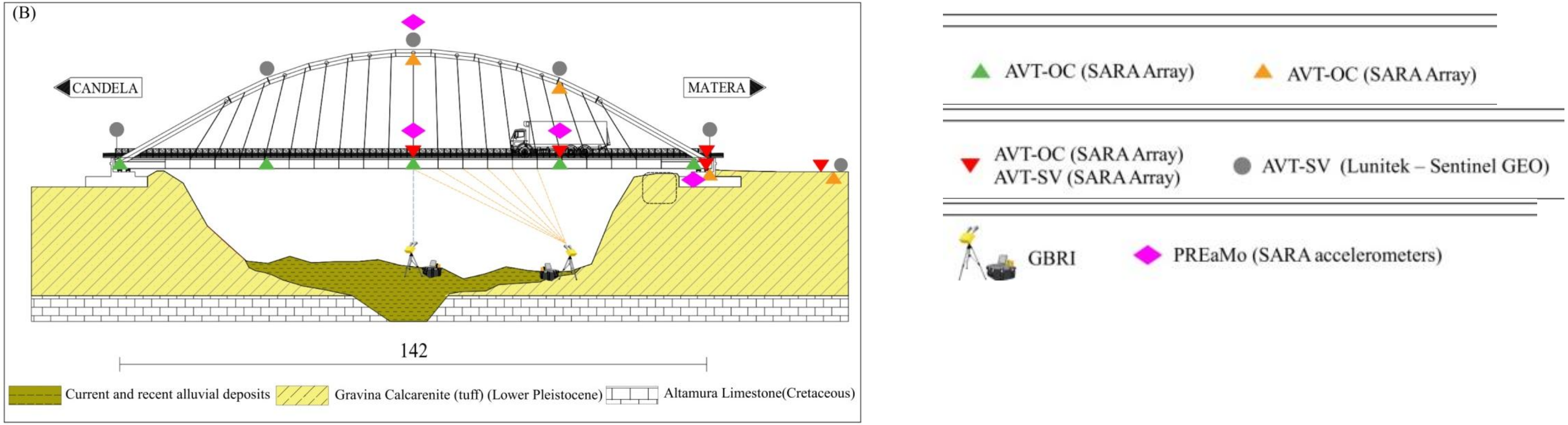
- The periodic monitoring of infrastructures, from a static and dynamic point of view, is required for identifying possible changes in the structure properties, in order to prevent serious damages and disasters;

- Structural Health Monitoring (SHM) may be defined as the use of in-situ, non destructive techniques for estimating the severity of damage deterioration on infrastructures.

PURPOSE OF THE STUDY

To verify the capability of an integrated geophysical approach by using non-invasive and non-destructive seismic and electromagnetic techniques to estimate the global characteristics (eigenfrequencies and damping factors) of the Gravina bridge located in Matera (Southern Italy).

GEOPHYSICAL INSTRUMENTATION and DATA



AVT – OC: ambient vibration tests – operating conditions: ambient seismic noise data – velocimetric data.

AVT – SV: ambient vibration tests – special vehicles: 40 tons trucks used as vibration exciters – velocimetric data.

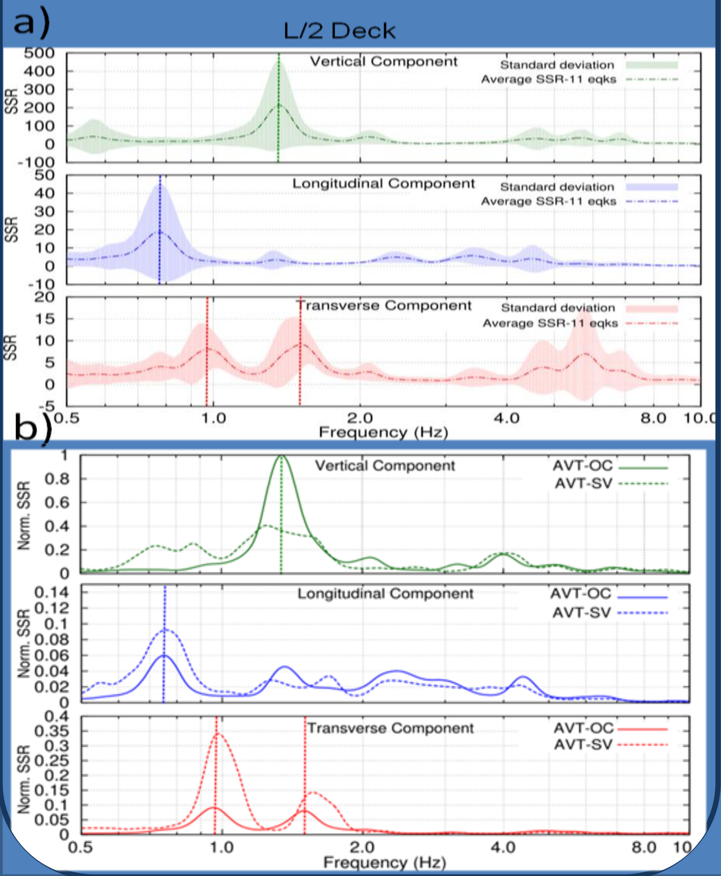
PREaMO: Permanent Real Time Earthquake Monitoring – accelerometric data (seismic data).

GBRI: Ground Based Radar wave Interferometry – electromagnetic data.

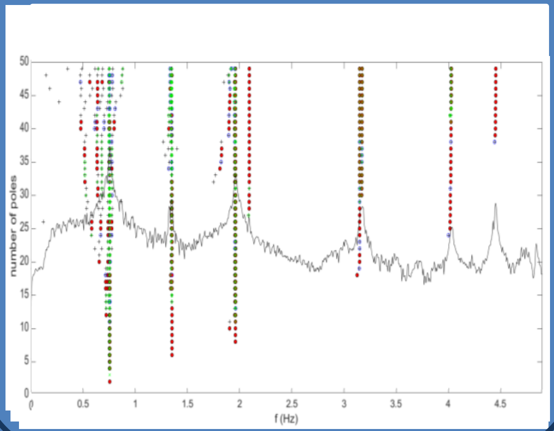
Eigenfrequencies determination

Online | 4–8 May 2020

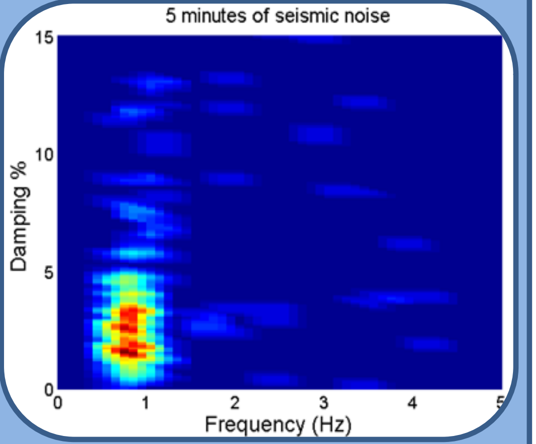
Standard Spectral Ratio (earthquake data and ambient vibration data)

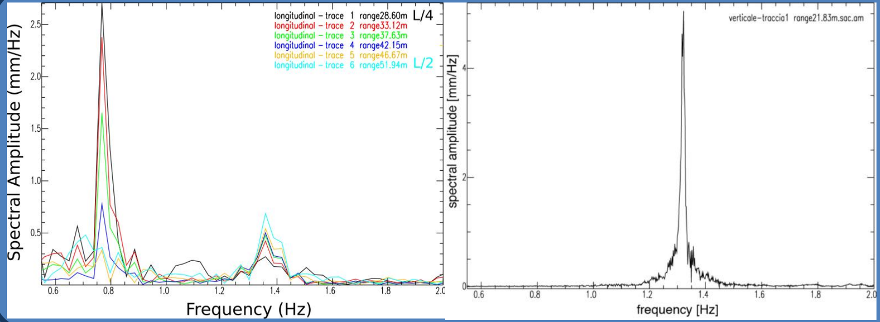


Operational Modal Analysis on ambient vibration data (Vertical Component)



Damping analysis





GBRI

Displacement spectra retrieved from the analysis of electromagnetic data

CONCLUSIONS

- We found strong consistency between results of different geophysical methods in the structural characterization of bridge;

- We described a reliable approach for monitoring infrastructures and their state of health;

- Non invasivity and fast-applicability of the methods and availability of remote sensing instruments allow to easily collect data in different time windows, for a proper Structural Health Monitoring of the infrastructure.

FURTHER DETAILS

MOTIVATION OF THE STUDY

- Civil infrastructures are crucial parts of the road asset and their possible degradation, with related consequences, may have great social, economical and safety impacts;

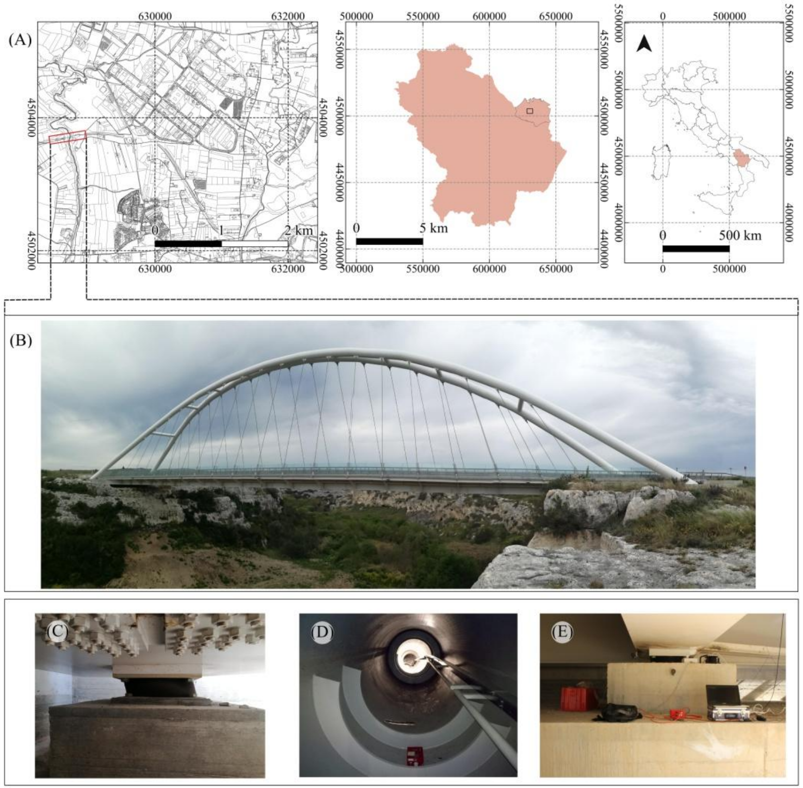
- The periodic monitoring of infrastructures, from a static and dynamic point of view, is required for identifying possible changes in the structure properties, in order to prevent serious damages and disasters;

- Structural Health Monitoring (SHM) may be defined as the use of in-situ, non destructive techniques for estimating the severity of damage deterioration on infrastructures.

PURPOSE OF THE STUDY

To verify the capability of an integrated geophysical approach by using non-invasive and non-destructive seismic and electromagnetic techniques to estimate the global characteristics (eigenfrequencies and damping factors) of the Gravina bridge located in Matera (Southern Italy).

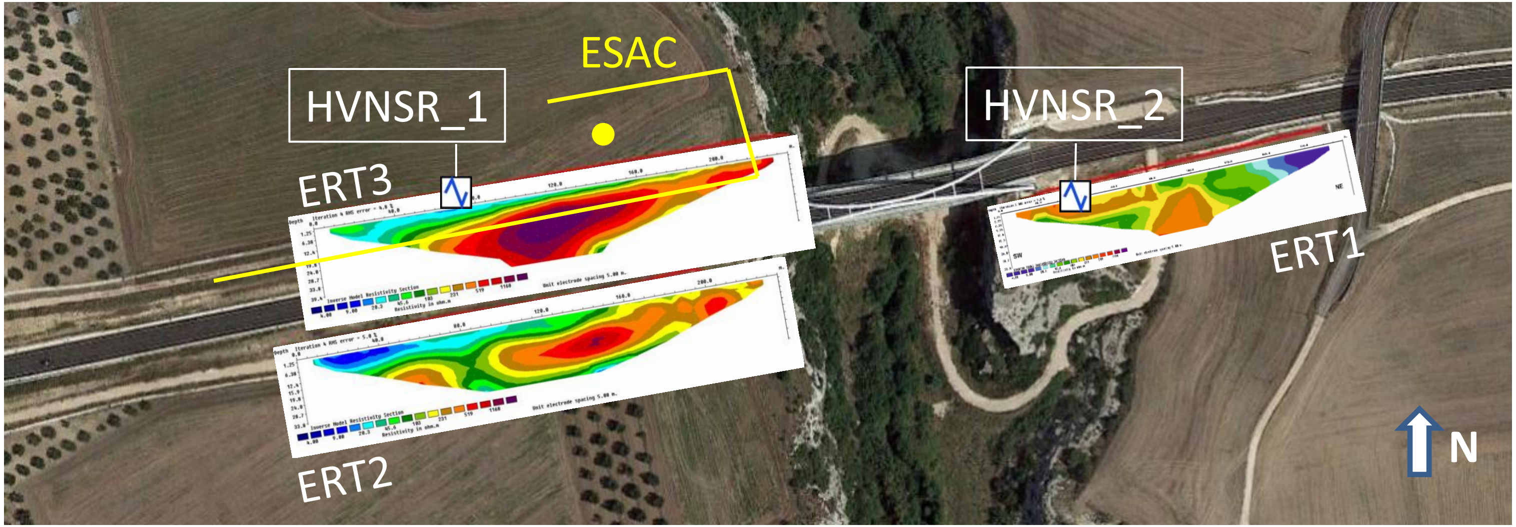
The GRAVINA BRIDGE



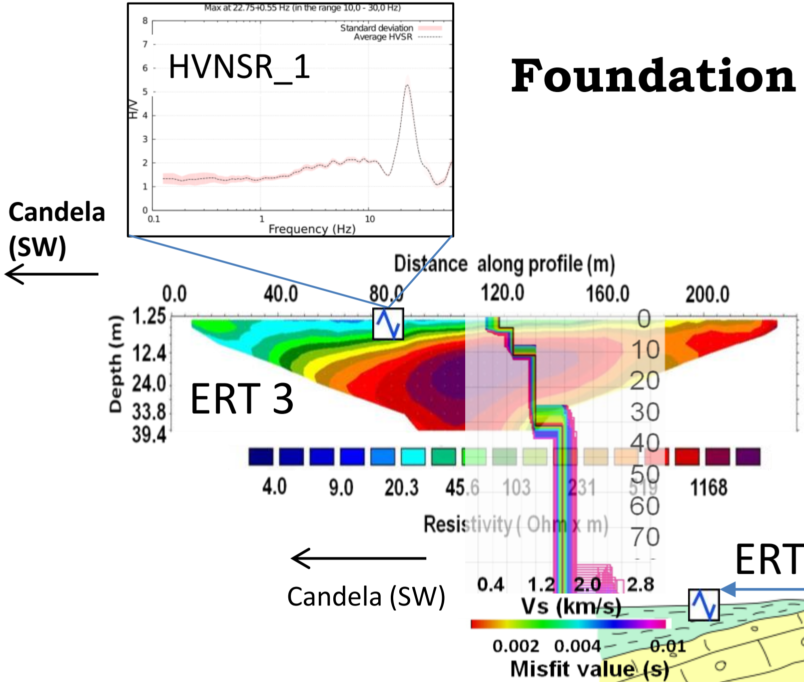
The Gravina Bridge is a newly constructed infrastructure located few km far from Matera, a small town in Basilicata, a southern region of Italy. This infrastructure develops for 144 m, along a steel-concrete deck. The suspension system, according to the Langer method, is made of 19 pair of fully locked coils, with fixed end on the arch side and adjustable on the deck end. The restraint system of the bridge is attained through eight elastomeric isolators.

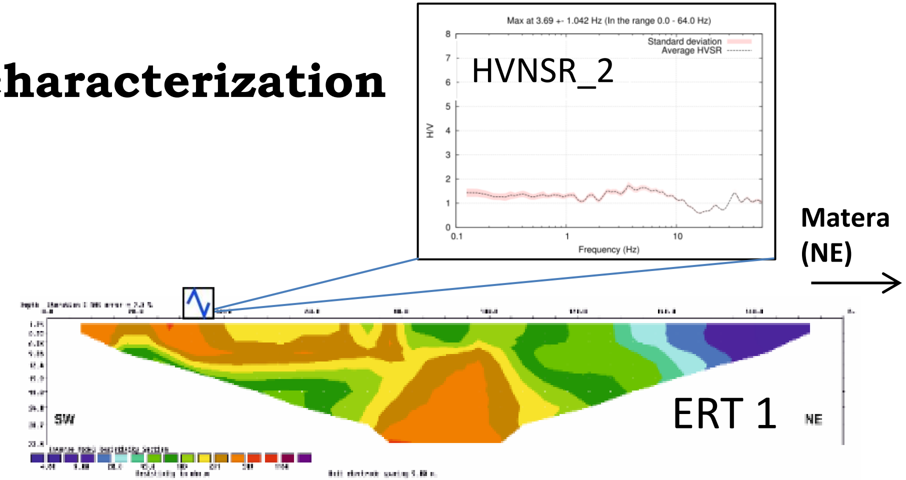
FOUNDATION SOIL CHARACTERIZATION

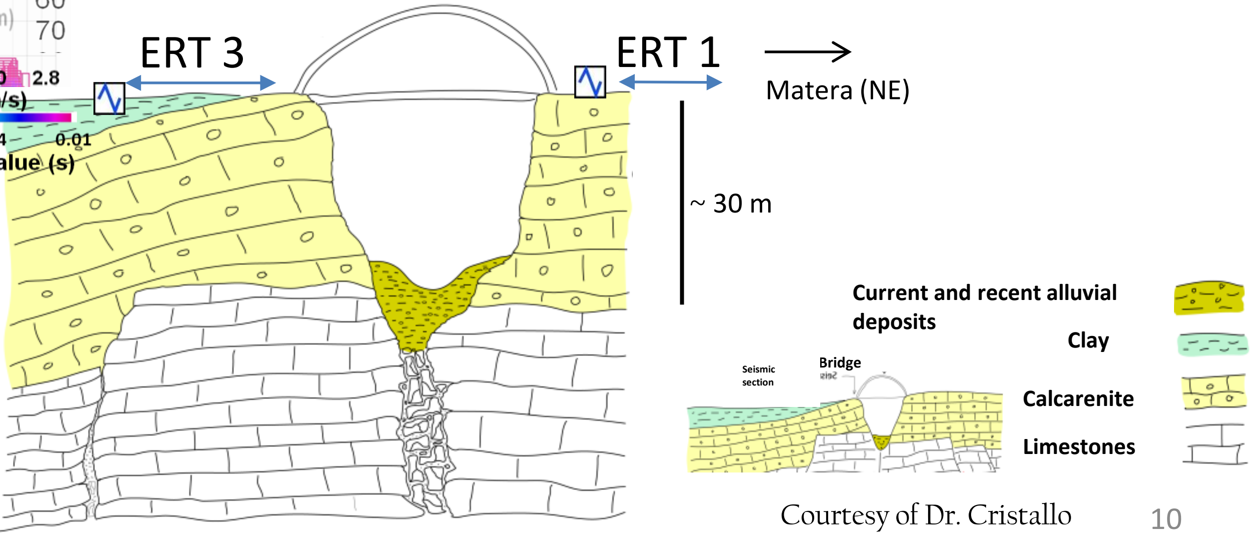
- 1 2D seismic array (ESAC)
- 2 Single station ambient seismic noise (HVNSR)
- 3 Electrical resistivity tomographies



Foundation soils characterization



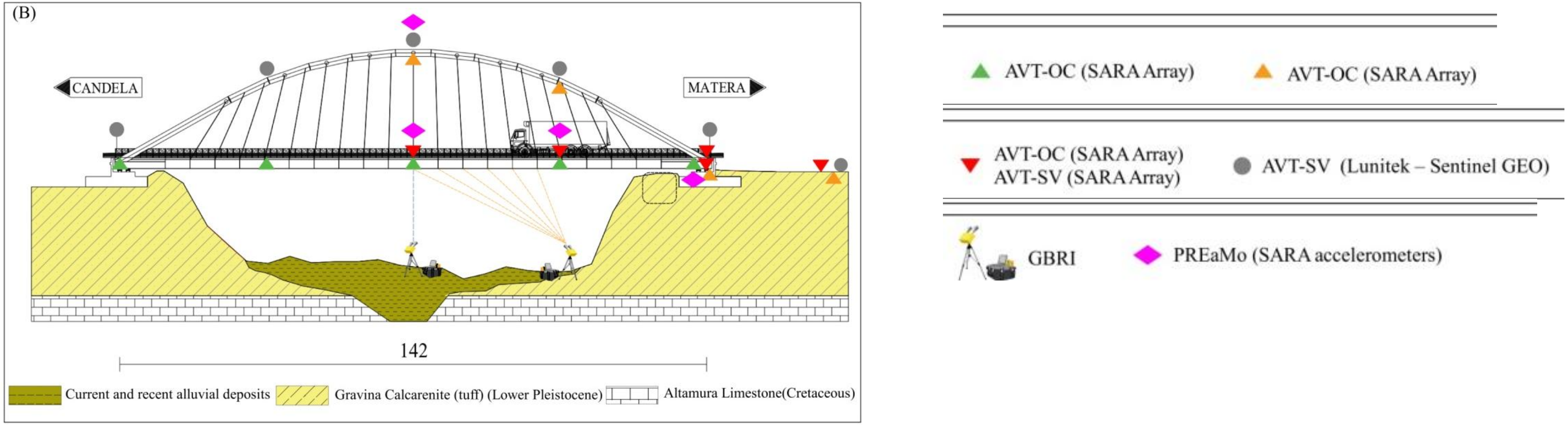




On Candela-side (SW) the bridge rests on calcarenitic rocks, subtly overlaid by a conductive layer of clays (see HVSR_1 and ERT3). On Matera-side (NE), the bridge rests just on calcarenitic rocks. Therefore, this side was chosen as the most appropriate for placing reference sensors for further seismic analyses.

Courtesy of Dr. Cristallo

GEOPHYSICAL INSTRUMENTATION and DATA



AVT – OC: ambient vibration tests – operating conditions: ambient seismic noise data – velocimetric data.

AVT – SV: ambient vibration tests – special vehicles: 40 tons trucks used as vibration exciters – velocimetric data.

PREaMO: Permanent Real Time Earthquake Monitoring – accelerometric data (seismic data).

GBRI: Ground Based Radar wave Interferometry – electromagnetic data.

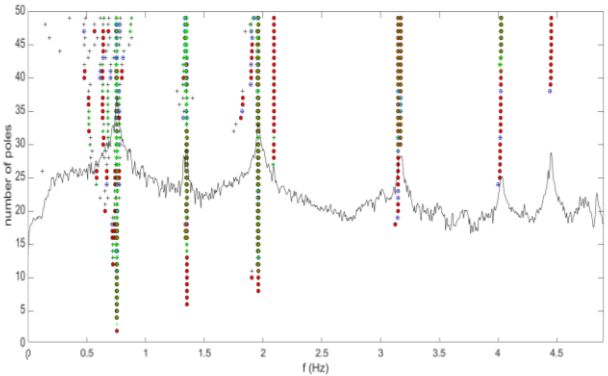
METHODS

Method	Data
Operational Modal Analysis	Ambient Vibration Tests – Operational Conditions (AVT-OC) data
Standard Spectral Ratio	Earthquake data; AVT – OC data; Ambient Vibration Tests – Special Vehicles (AVT – SV) data
S- transform	Earthquake data
Damping Analysis	AVT – OC data
Ground Based Radar wave Interferometry (GBRI)	AVT – SV data

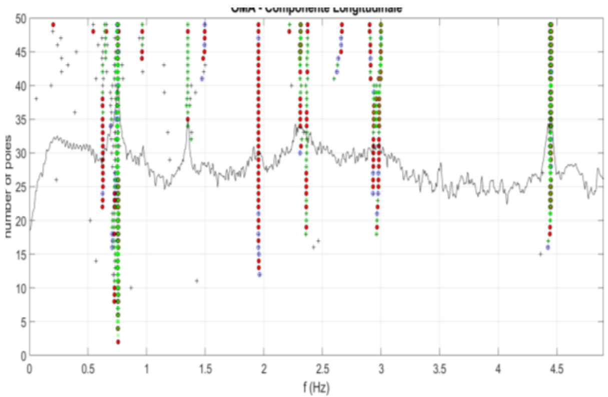
- Eigenfrequencies in different deck and arch points (0L, L/4, L/2, where L represents the longitudinal extension of the bridge)
- Equivalent viscous damping factor

Operational Modal Analysis

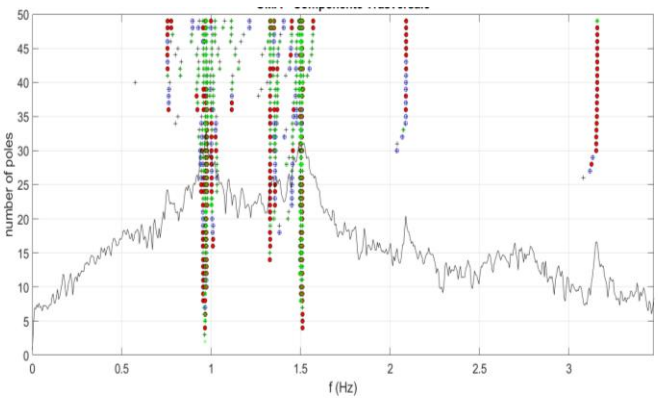
Vertical component



Longitudinal component



Transverse component



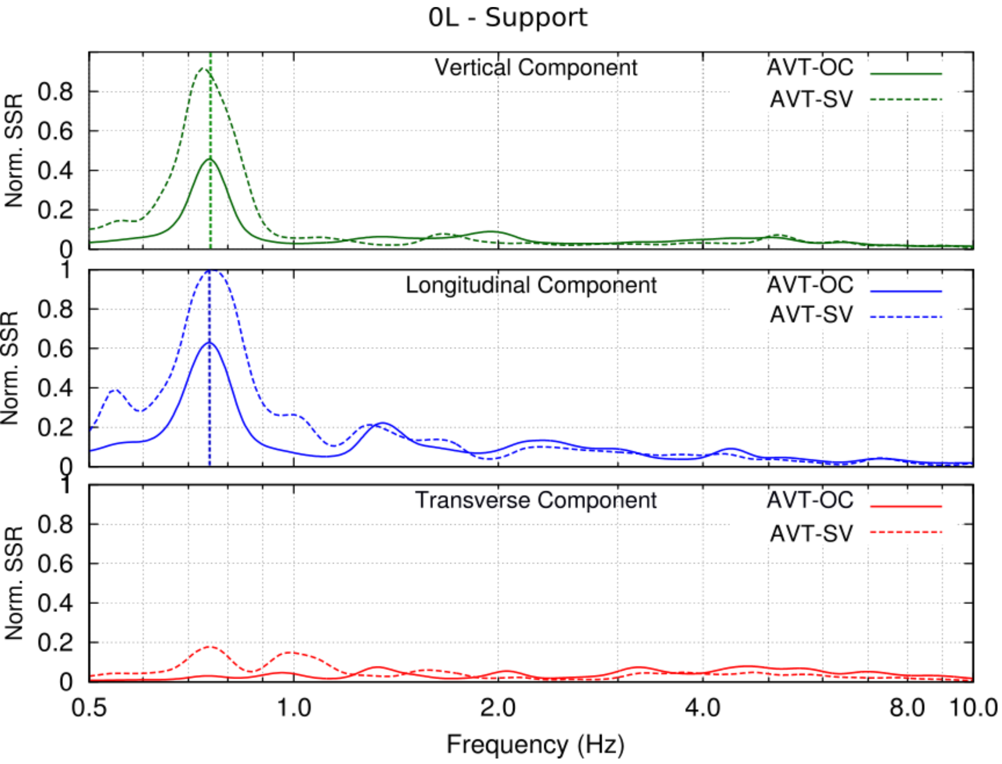
+ new pole ● stable pole ○ stable freq. & MAC □ stable freq. & damp. × stable freq.

The principal modes are clearly identified: the 1st mode is at 0.76 Hz in the vertical and longitudinal component, the 2nd at 0.97 Hz evident in the transversal component, the 3rd mode at about 1.35 Hz in the vertical and longitudinal component and the 4th and the 5th in the transversal component at 1.50 Hz and 2.2 Hz, respectively.

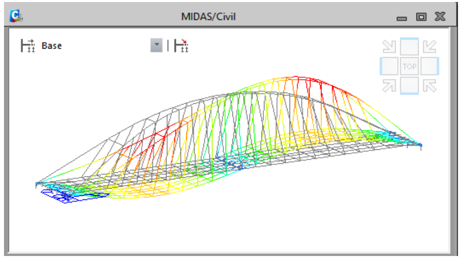
Standard Spectral Ratio analyses

EGU General Assembly 2020

Bridge eigenfrequencies determination

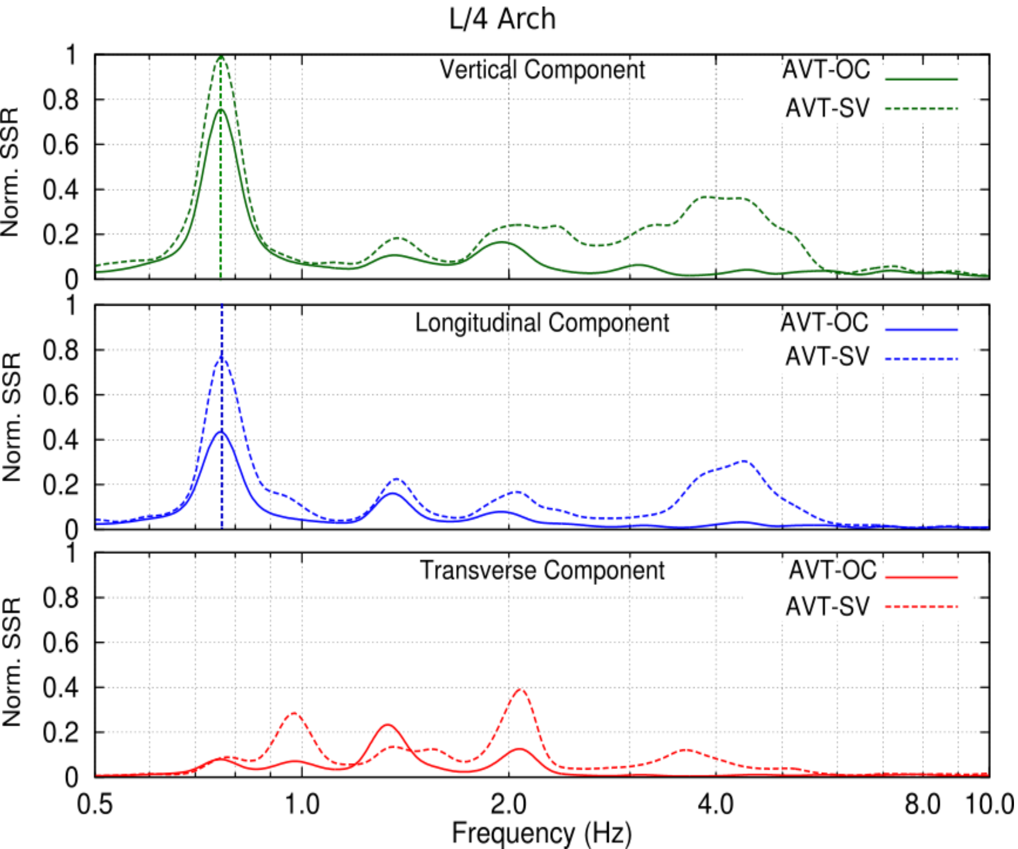


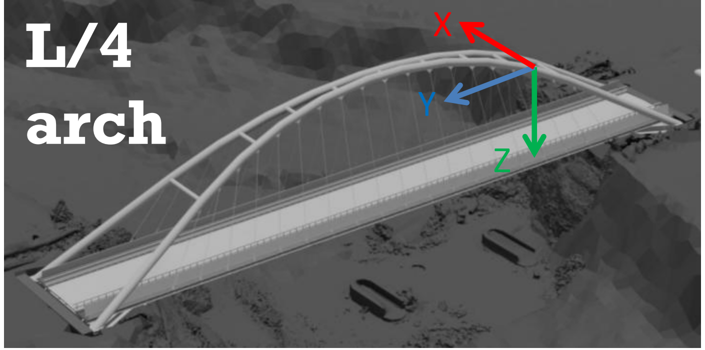
0.75 Hz: 1st mode of vibration of the structure



EGU General Assembly 2020

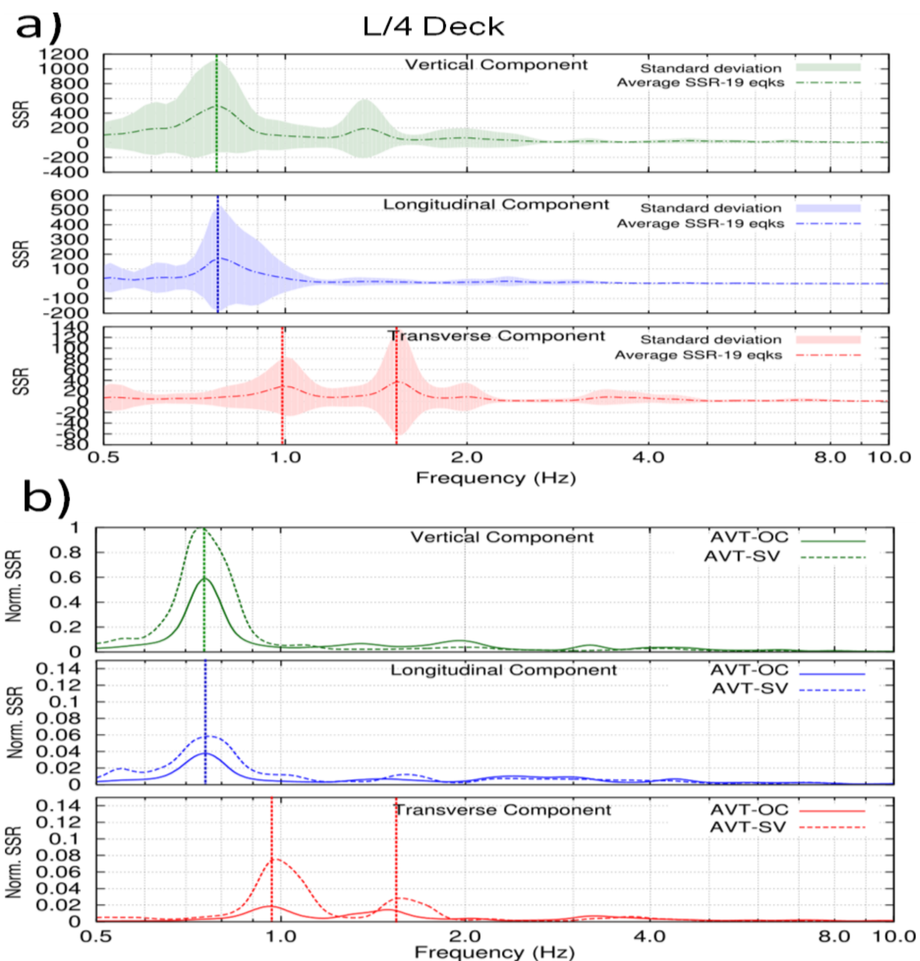
Bridge eigenfrequencies determination

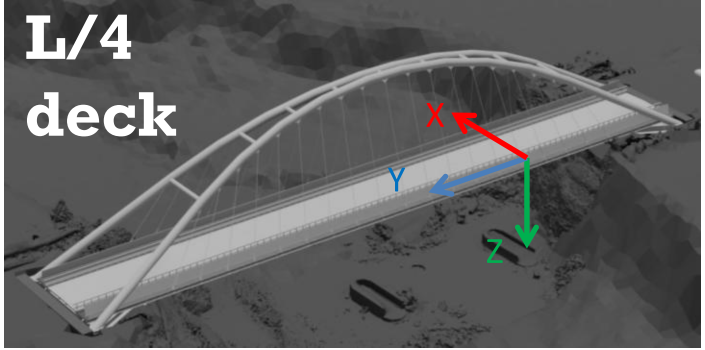




- Main peaks on the vertical and longitudinal components, at about 0.75 Hz (first mode of vibration);
- vertical and longitudinal SSRs show a very good agreement between results obtained through AVT – OC and AVT – SV data analyses.

Bridge eigenfrequencies determination

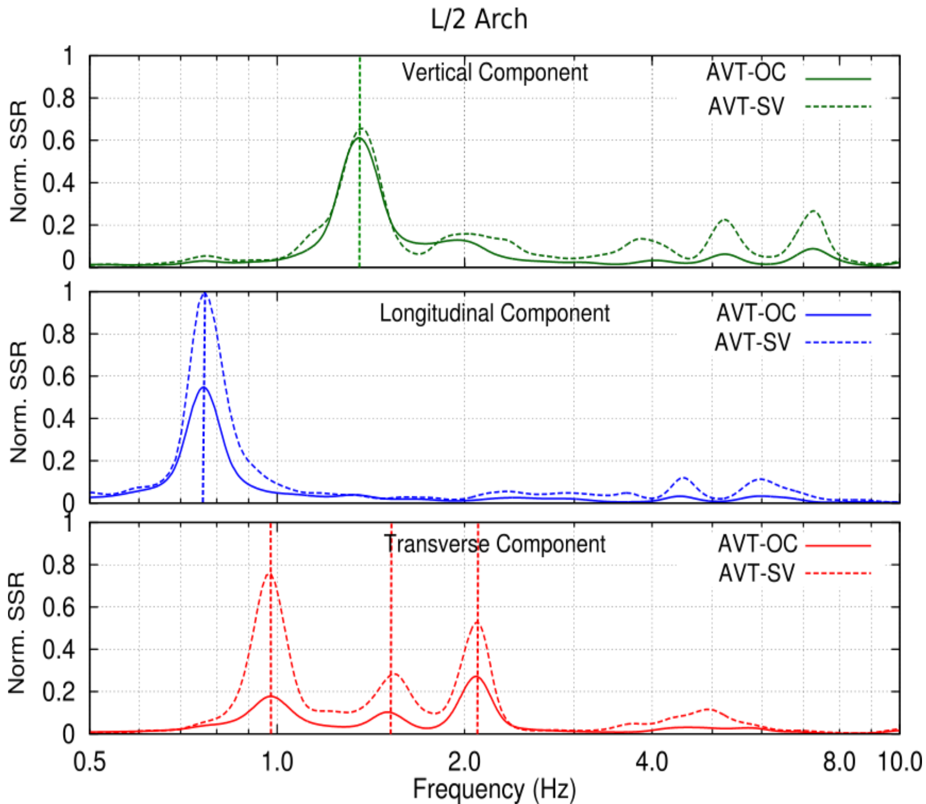


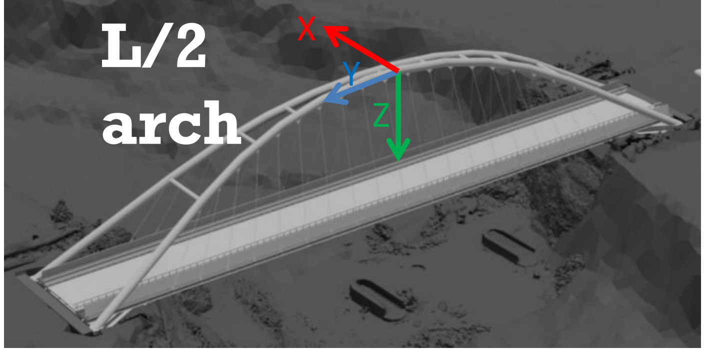


- the 1st mode is at 0.75 Hz, both on the longitudinal and vertical component;
- the amplitude of 1st mode peak is higher on the vertical than on the longitudinal one;
- there is a very good agreement between results obtained from the analyses of different data (AVT and earthquake data).

EGU General Assembly 2020

Bridge eigenfrequencies determination





All principal vibration modes are evident:

-the 1st mode at 0.75 Hz in the longitudinal SSR function;

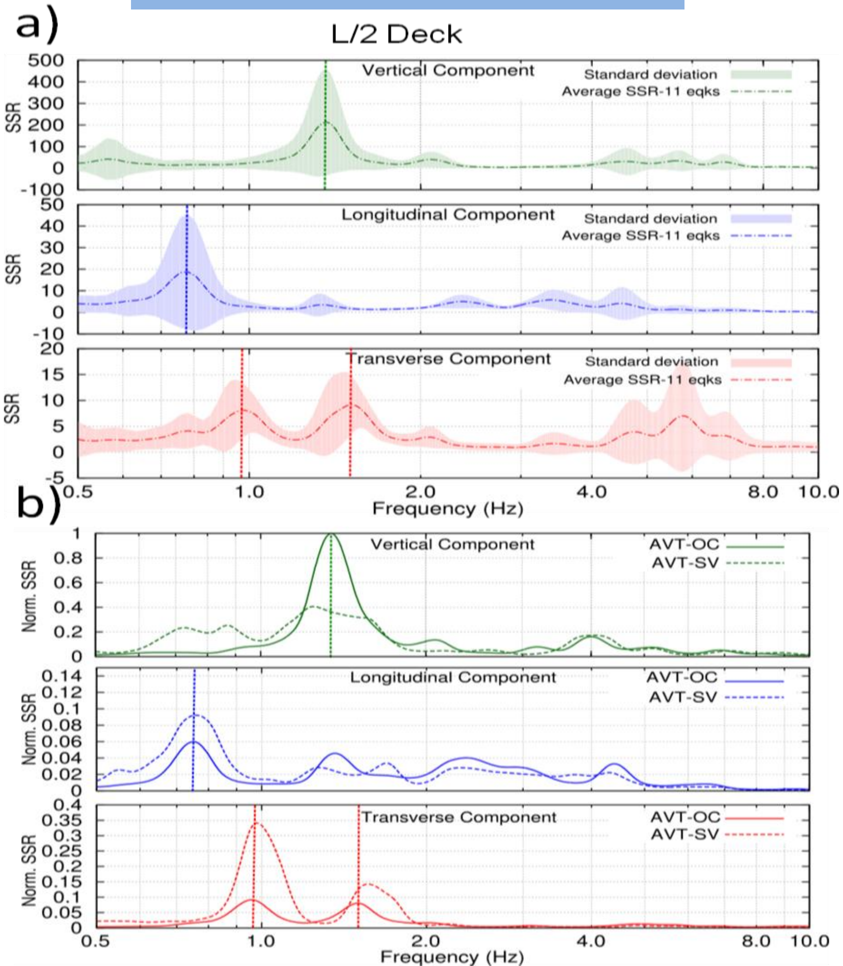
- the 2nd at 0.95 Hz in the transversal component;

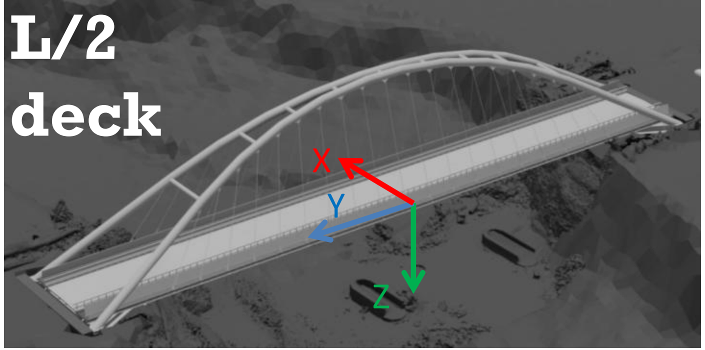
- the 3rd at 1.3 Hz in the vertical component;

-the 4th and 5th at 1.5 Hz and 2.2 Hz respectively in the transversal component.

We still observe good agreement between SSR functions obtained through analysis of AVT – OC and AVT – SV data.

Bridge eigenfrequencies determination





The same eigenfrequences determined on the arch were retrieved on the deck:

-the 1st mode at 0.75 Hz in the longitudinal SSR function;

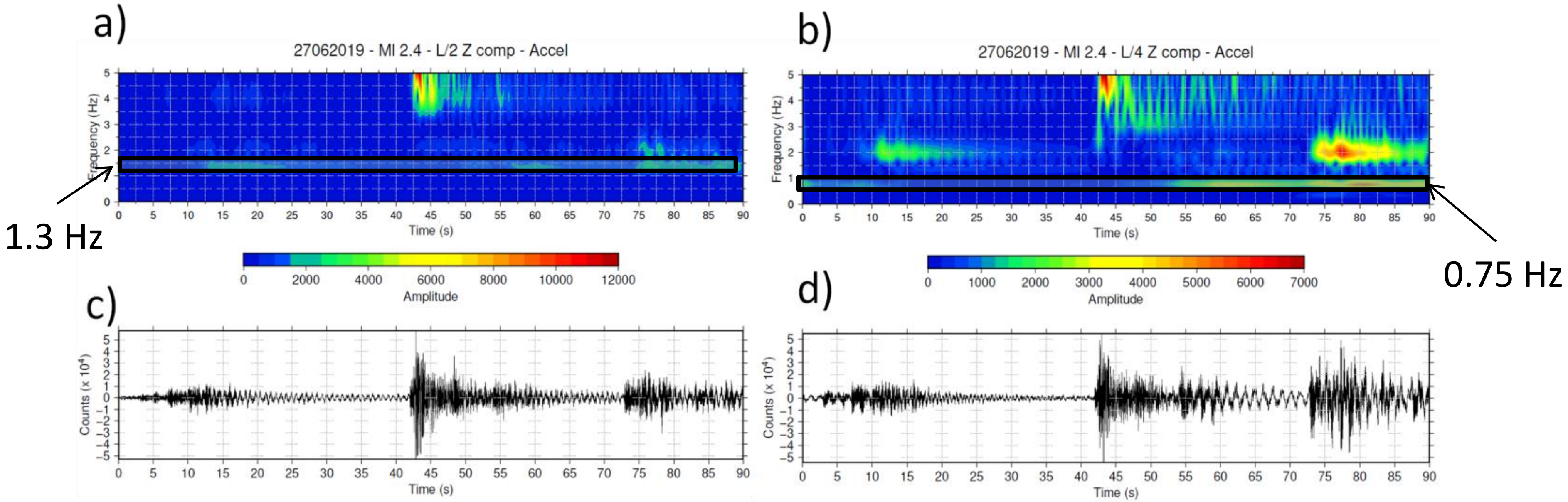
- the 2nd at 0.95 Hz in the transversal component;

- the 3rd at 1.3 Hz in the vertical and longitudinal component;

- and the 4th at 1.5 Hz in the transversal component

S-transform

Data: Accelerometric signals related to Ml 2.4 earthquake, 5 km far from the bridge.



The 1st mode at 0.76 Hz estimated at L/4 on deck and the 3rd mode at 1.3 Hz at L/2 on deck are evident before and after the wave train of weak motion; in addition, the earthquake signal induces vibrations at higher frequencies, greater than 4 Hz.

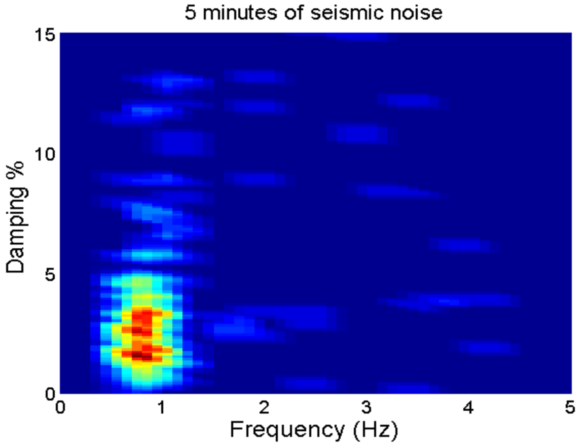
EGU General Assembly 2020

Damping analysis

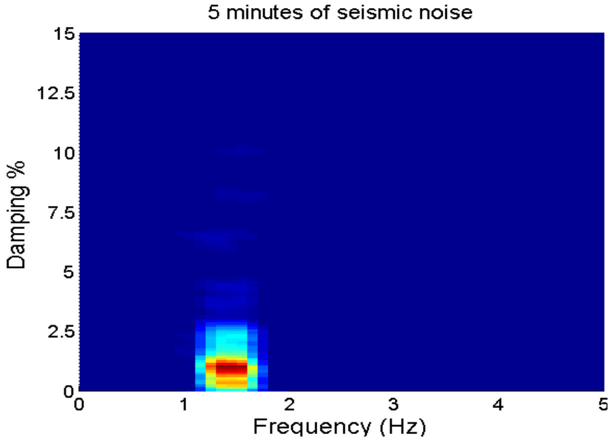
Online | 4–8 May 2020

Equivalent damping viscous factor analysis on 5 minutes of seismic noise recorded by the vertical component of accelerometers installed at L/4 (deck) and L/2 (arch and deck).

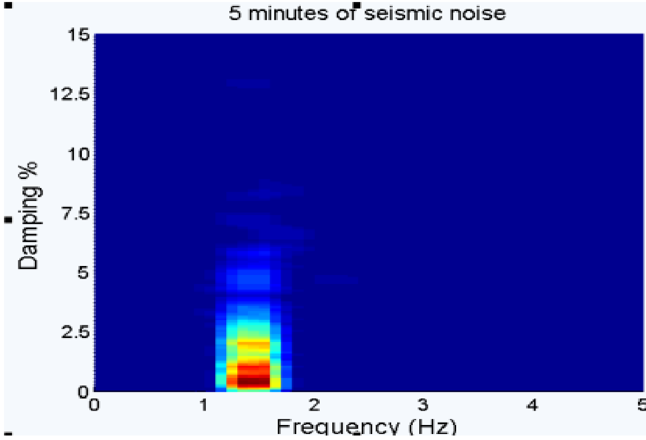
L/4 deck



L/2 arch

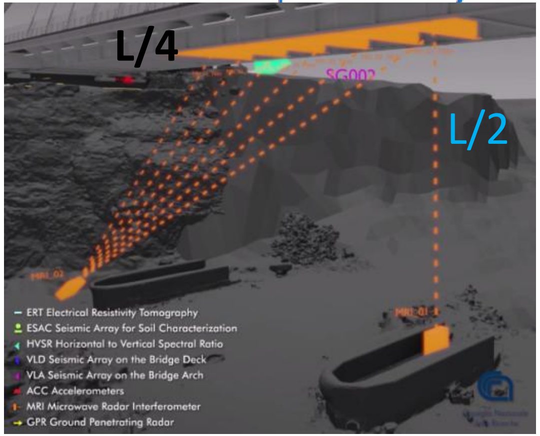


L/2 deck

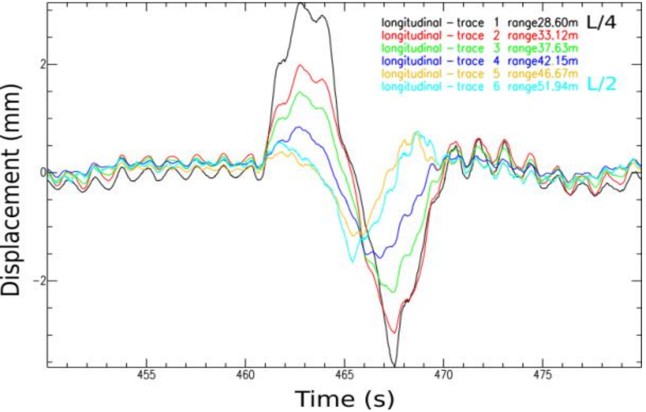


The damping analysis, in addition to providing the percentage of damping at different points of the infrastructure, estimates the main frequencies of vibration of the bridge.

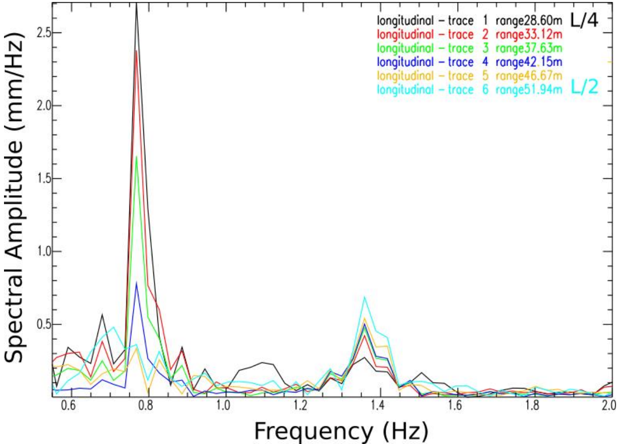
GBRI



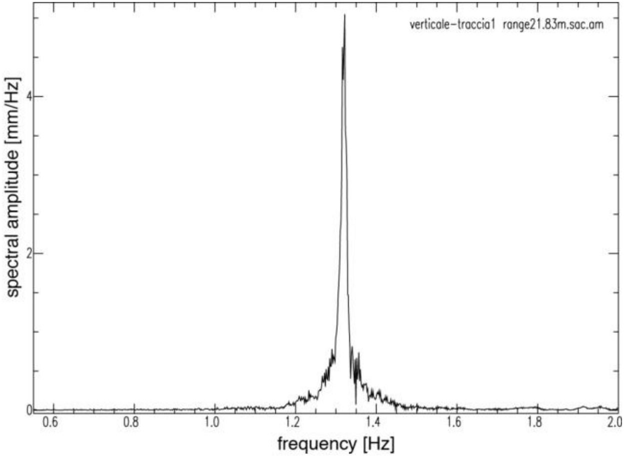
Longitudinal configuration



Long. Configuration (several points, from L/4 to L/2, were illuminated)
: from L/4 to L/2 the 0.75 Hz peak, describing the 1st mode of vibration, gradually decreases, as already observed in the former seismic analysis.



Vertical configuration



Vert. Configuration (only the point at L/2 is illuminated):
1.3 Hz peak is retrieved, representing the 3rd mode od vibration of the structure.

CONCLUSIONS

- We found strong consistency between results of different geophysical methods in the structual characterization of bridge;

- We described a reliable approach for monitoring infrastructures and their state of health;

- Non invasivity of the methods and availability of remote sensing instruments allow to easily collect data in different time windows, for a proper Structural Health Monitoring of the infrastructure.