THE UNIVERSITY OF WESTERN AUSTRALIA

# STRUCTURAL HEALTH MONITORING OF COMPOSITE BRIDGES WITH A RELATIVE DISPLACEMENT SENSOR

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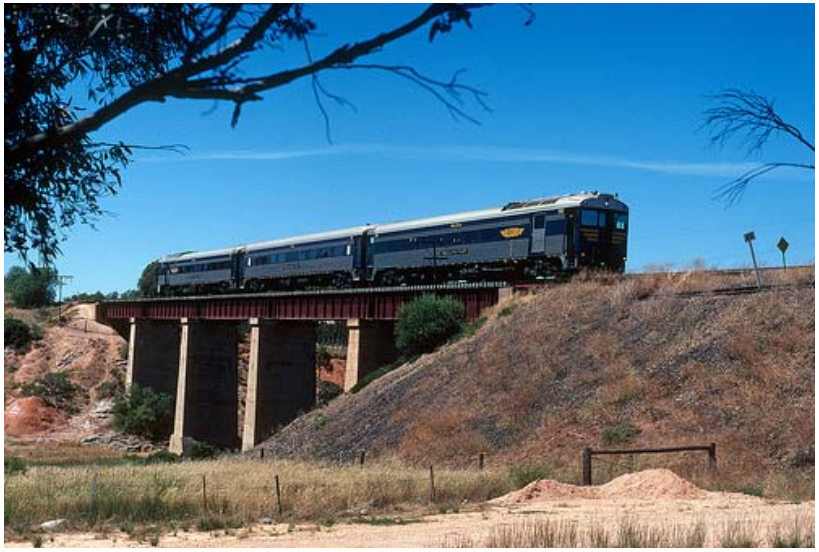
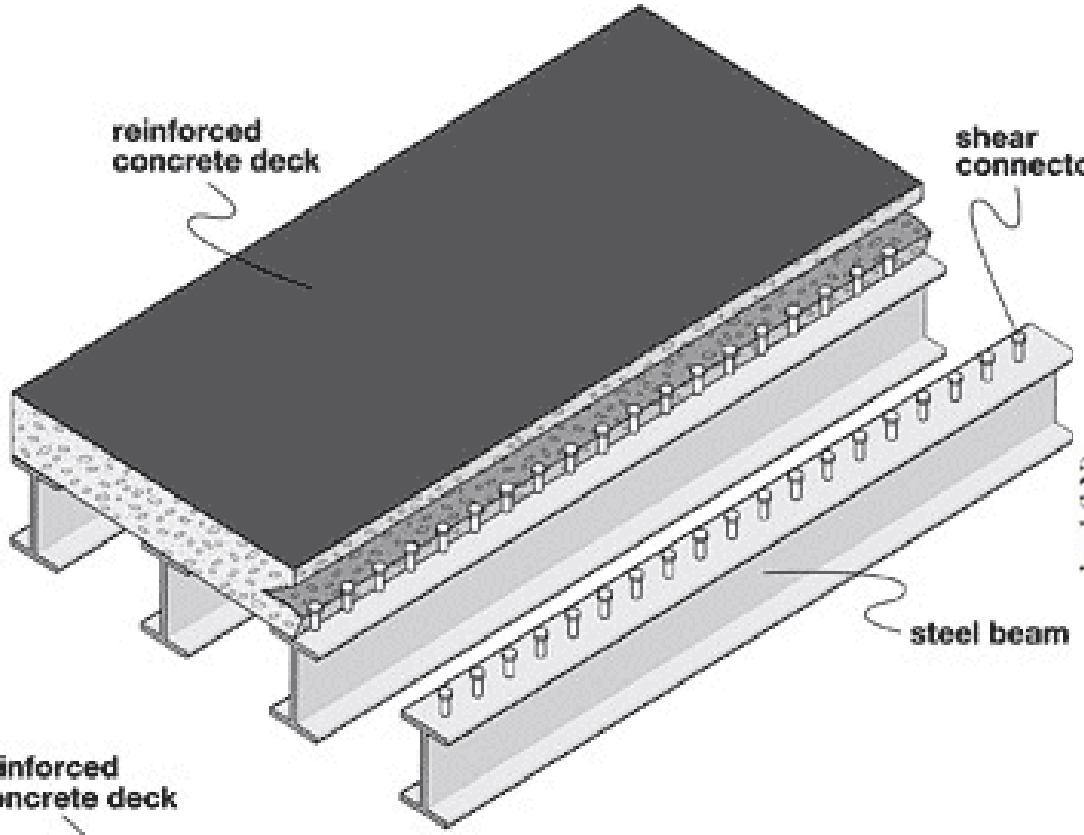
ACHIEVE INTERNATIONAL EXCELLENCE

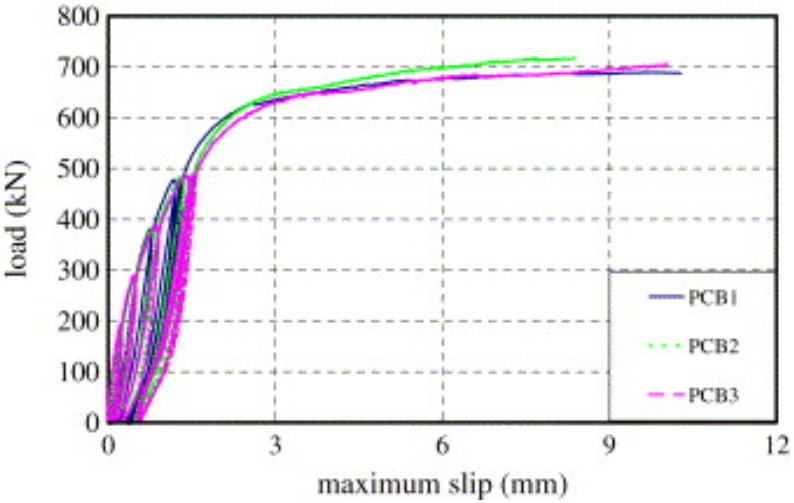
# Introduction

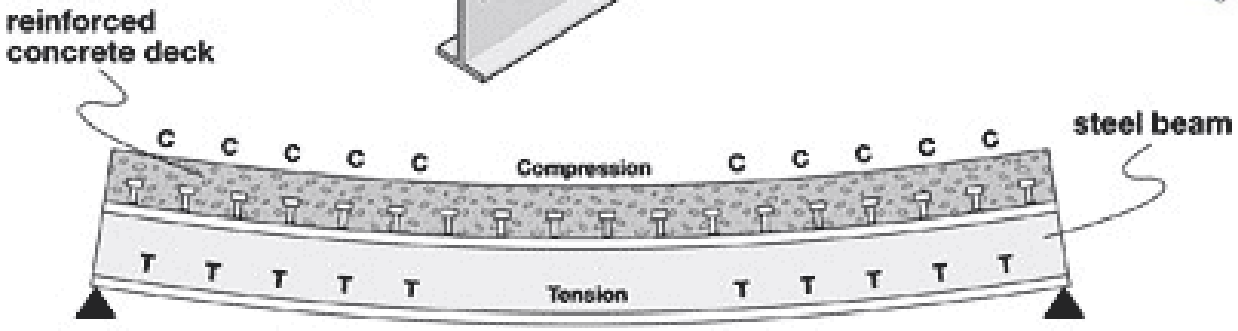
## Australian composite bridges

- Short/Medium span
- Mostly built 30/40 years ago
- Concrete slab/ Concrete(Steel) girder





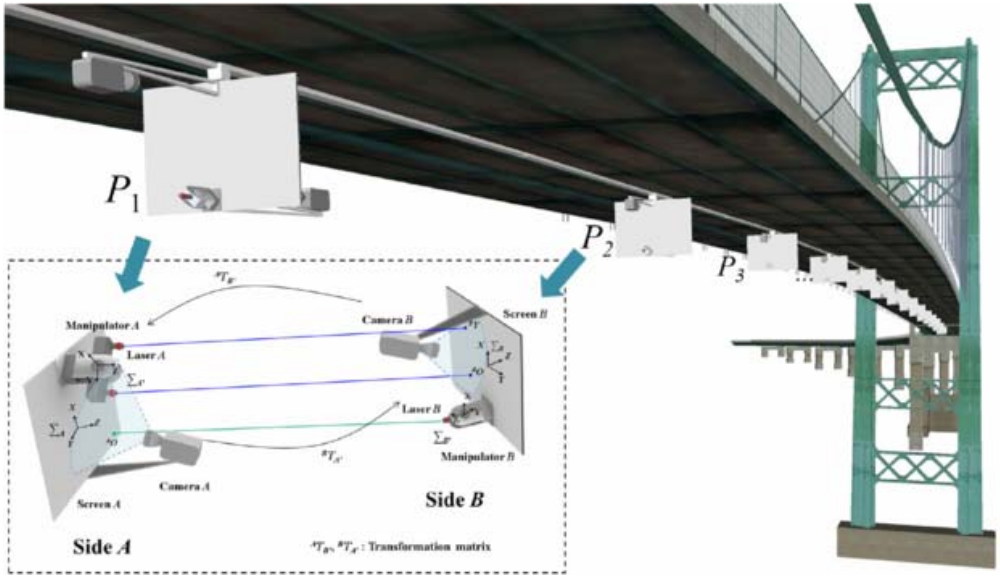




note: curvature greatly exaggerated to show composite effect

# Displacement measurement

LVDT (Contact)

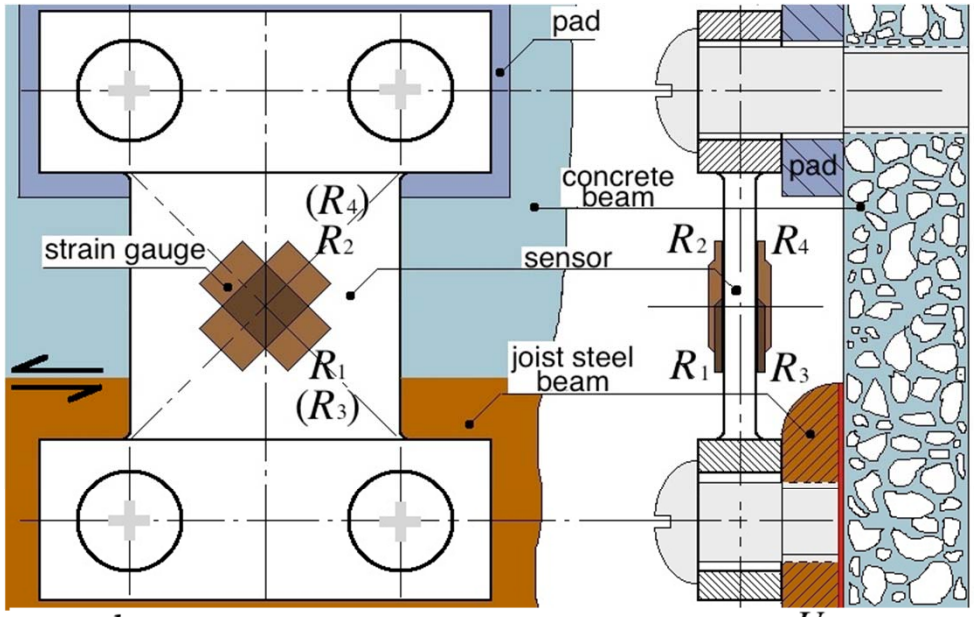
Camera (Non-contact)

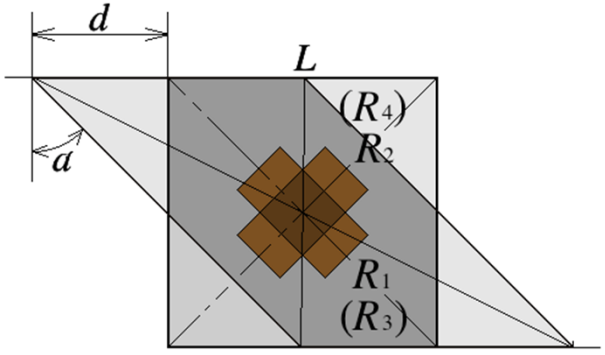


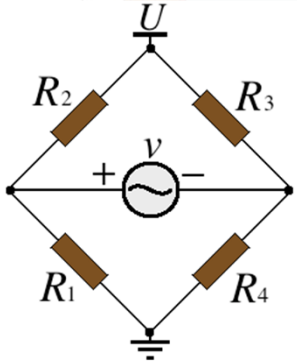

Need to setup fixed reference point

Time consuming in signal processing

# Relative displacement sensor



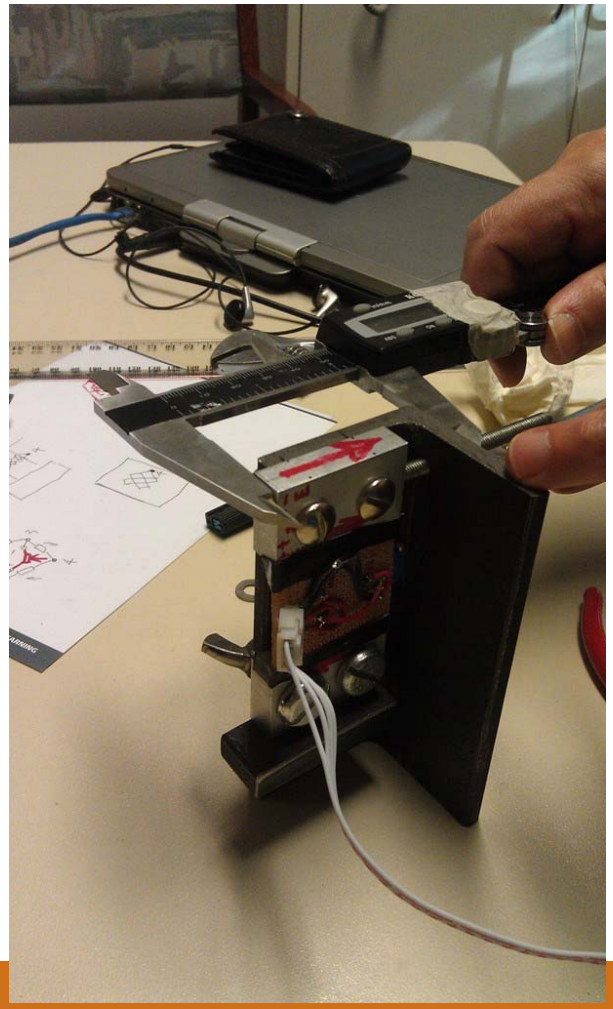



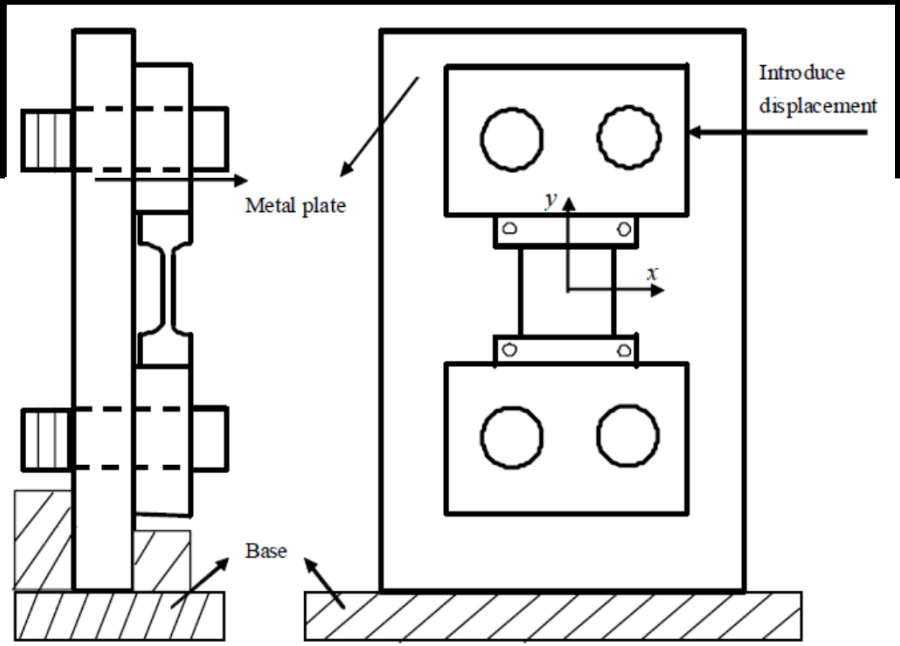




*Sensor prototype*

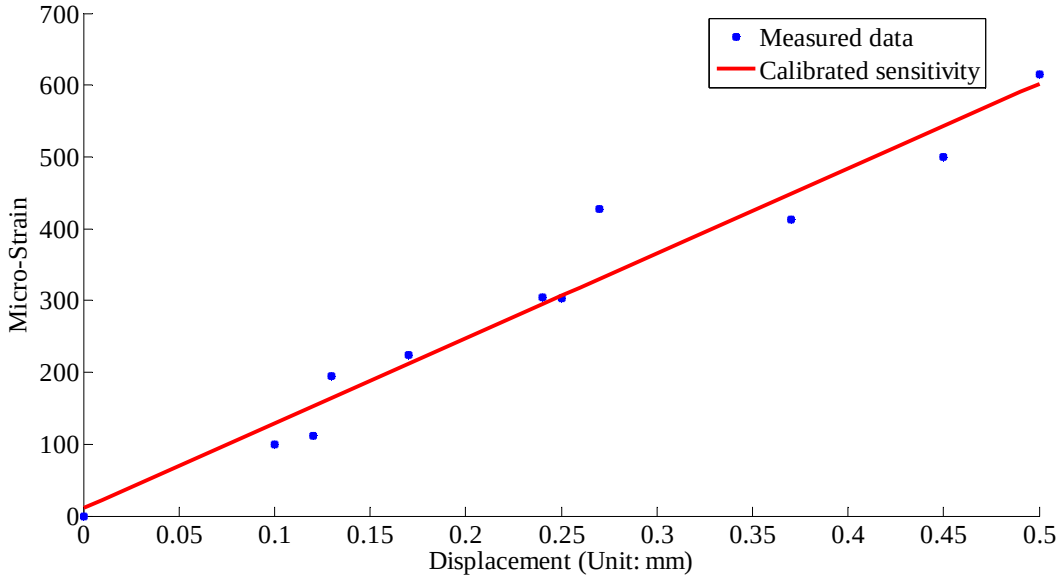
Wheatstone bridge circuit

# Sensor Calibration






Sensitivity: K = 1182.82

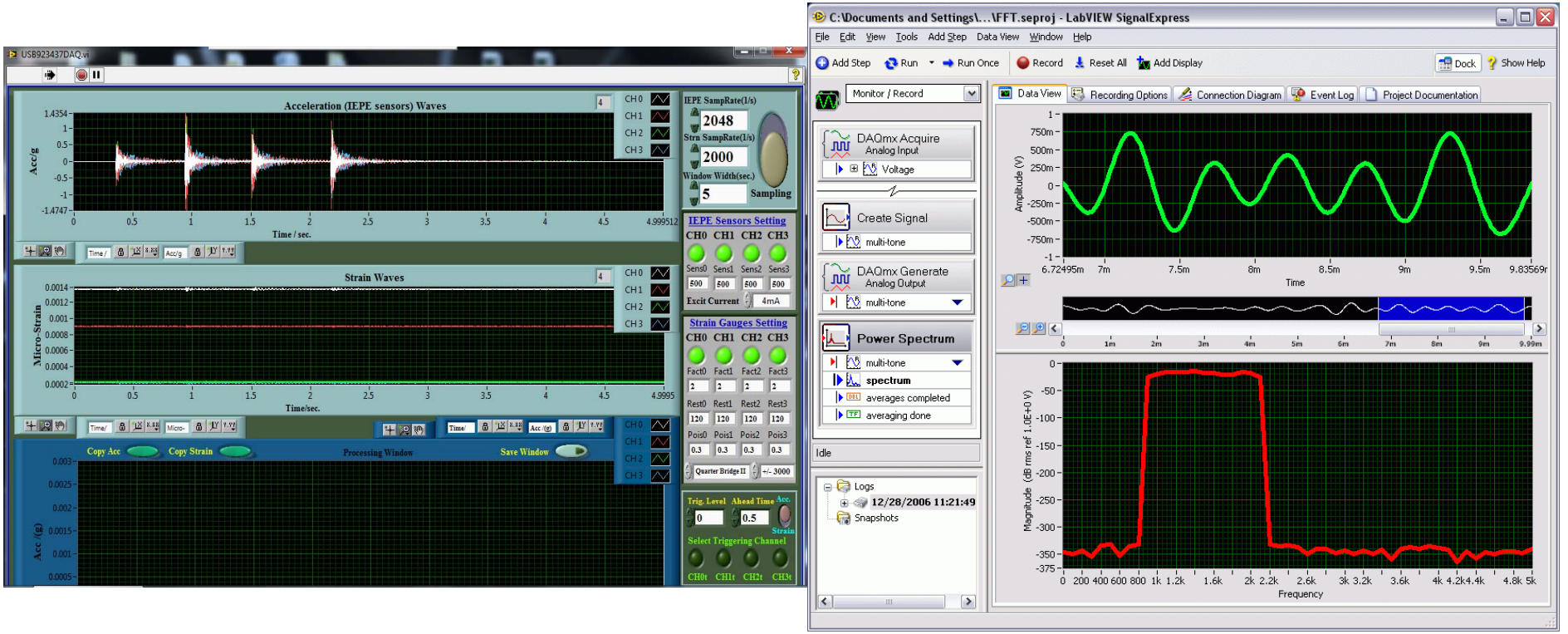


# Sensor Installation

- Contact, Easy to setup
- Fast recording and processing
- No reference point
- Cost effective

↘ 4 relative displacement sensors

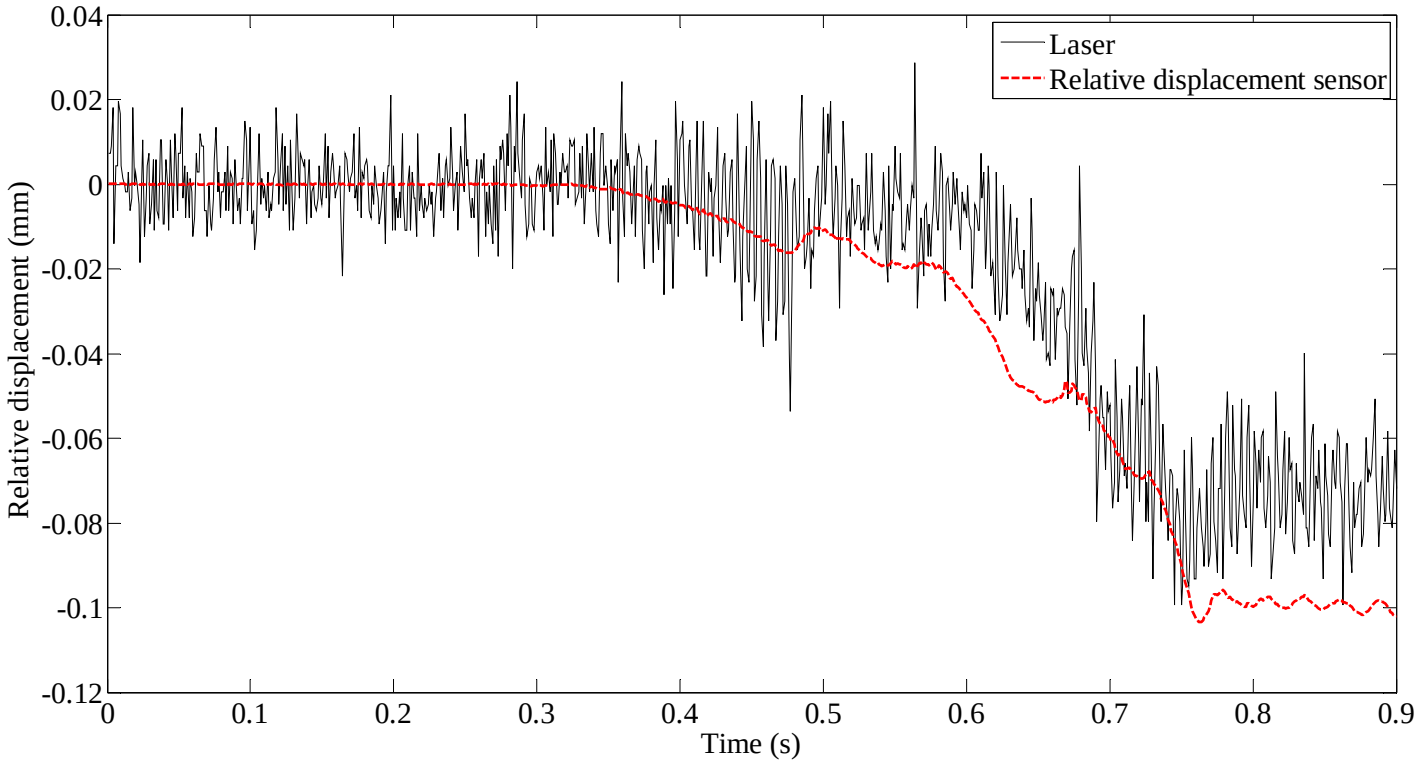
# Data recording and analysis program



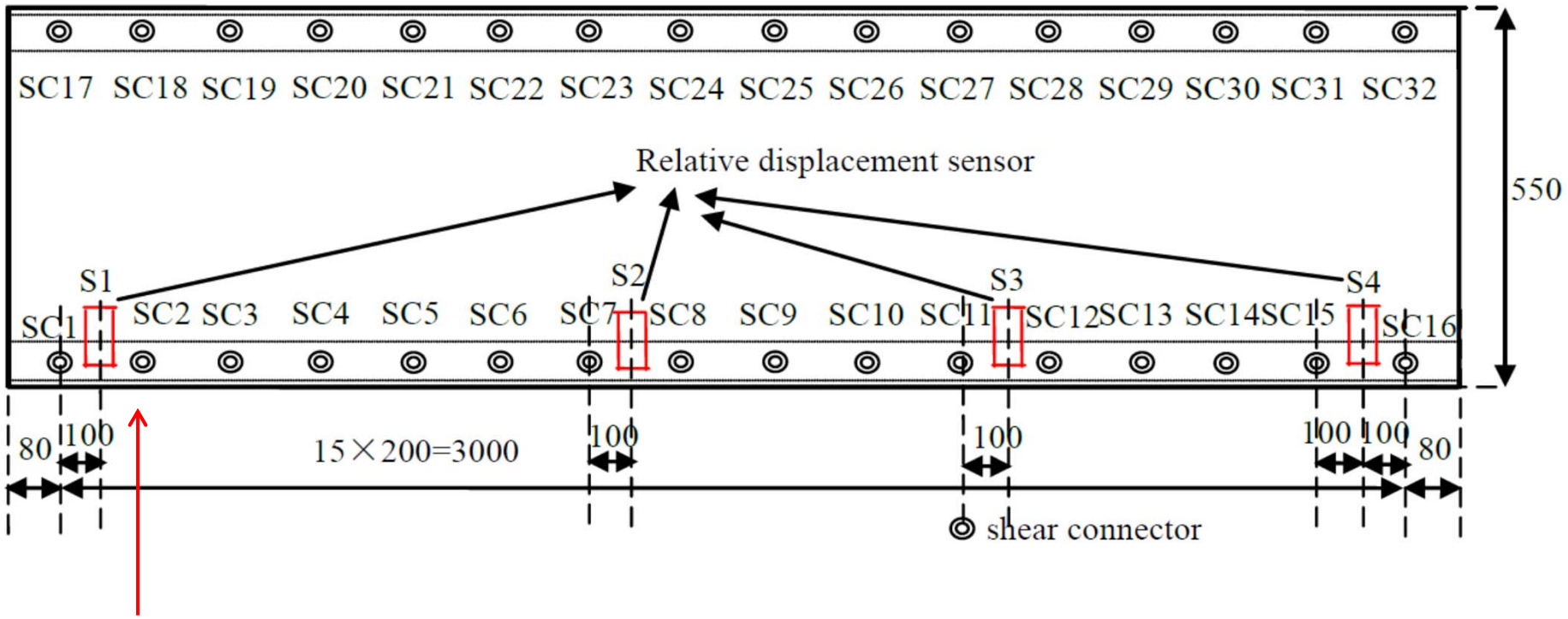

- Based on Labview
- NI Labview SignalExpress

# Sensor Verification


# Verification Results

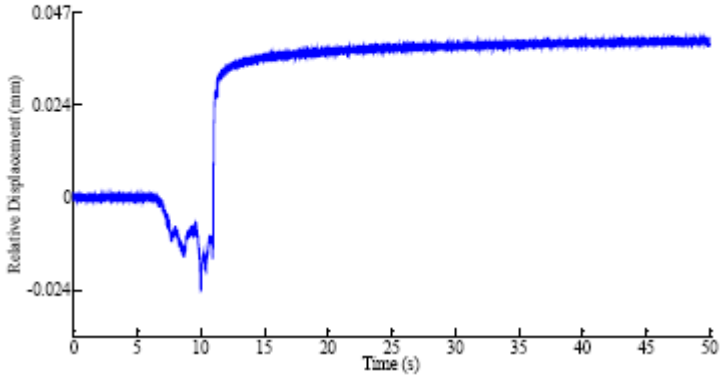


# Sensor locations and shear connectors

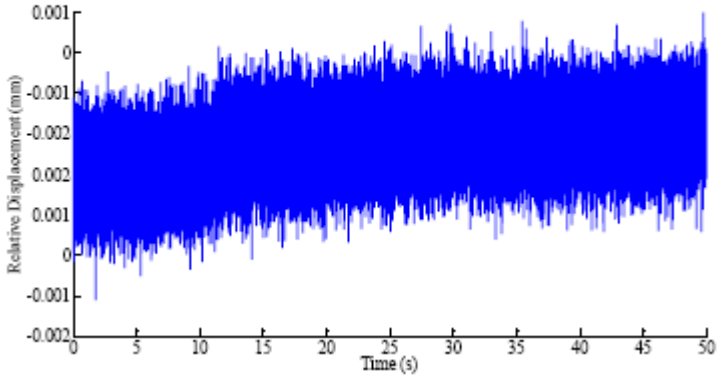


# Failure detection of shear connectors SC1

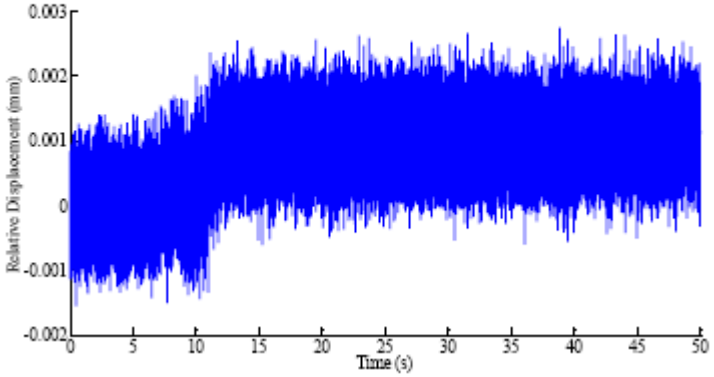
(a) S1



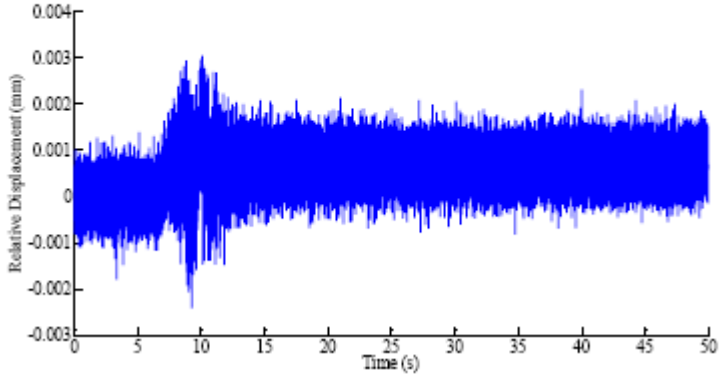

(b) S2




(c) S3

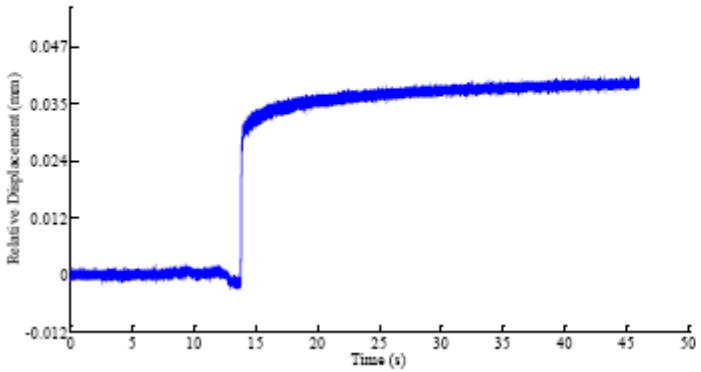



(d) S4

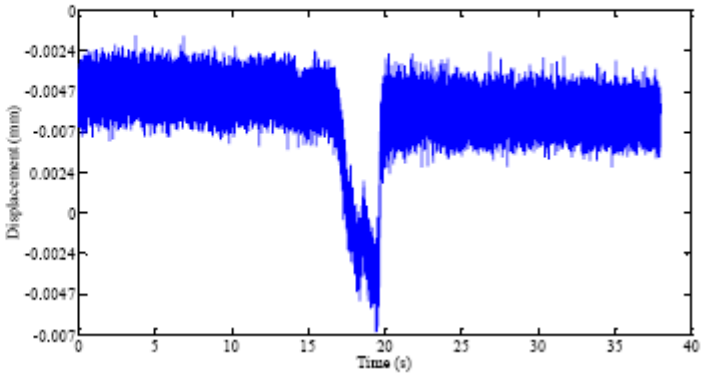


# Sensitivity radius of the relative displacement sensor

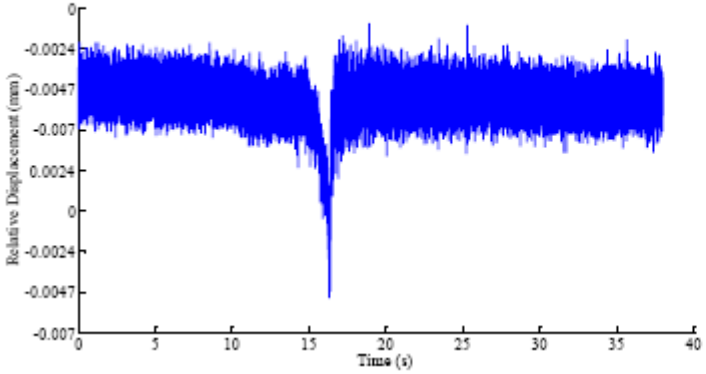
(a) Releasing SC2



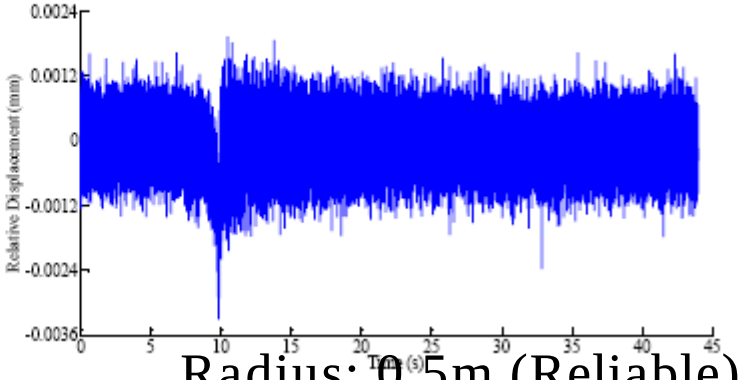

(b) Releasing SC4




(c) Releasing SC6




(d) Releasing SC8




Radius: 0.5m (Reliable) -0.9m

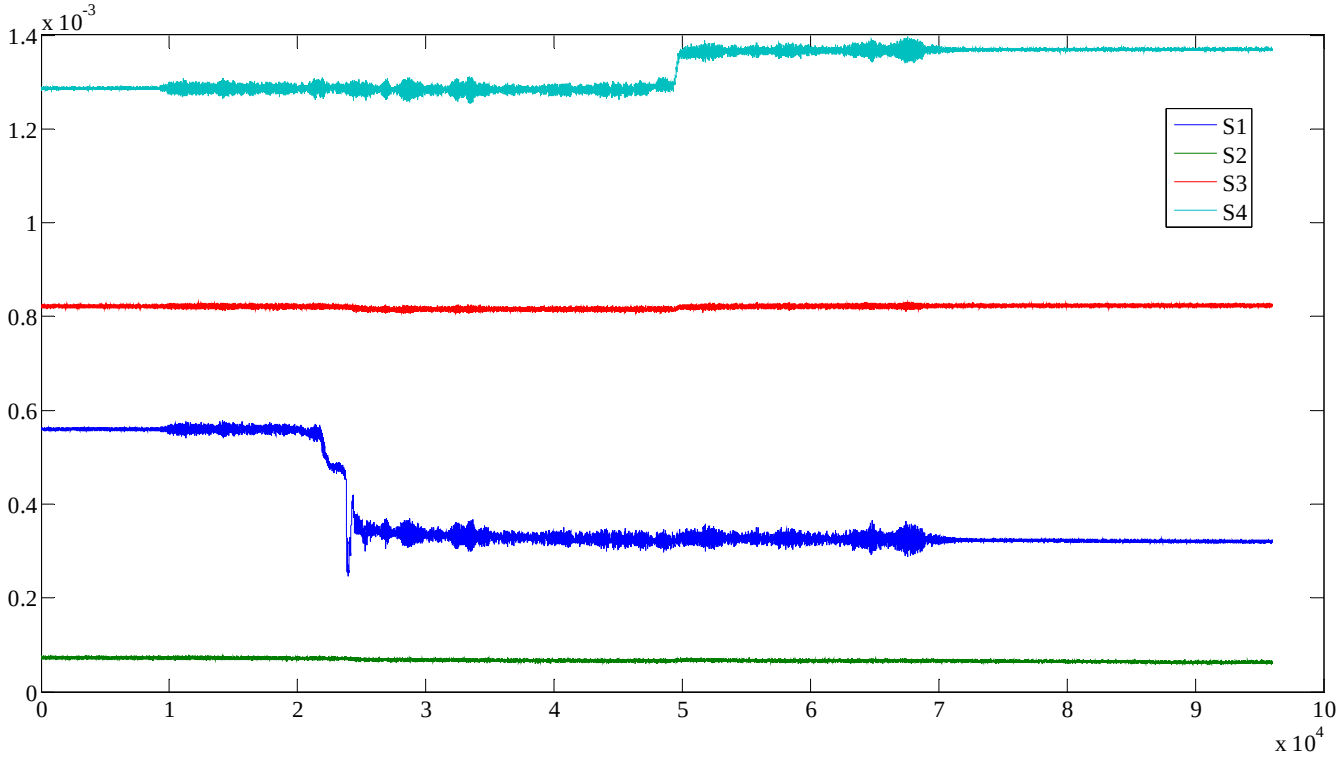
# On-line monitoring under ambient vibration

*An exciter on the bridge*

- *White noise*
- *Sweep sine*

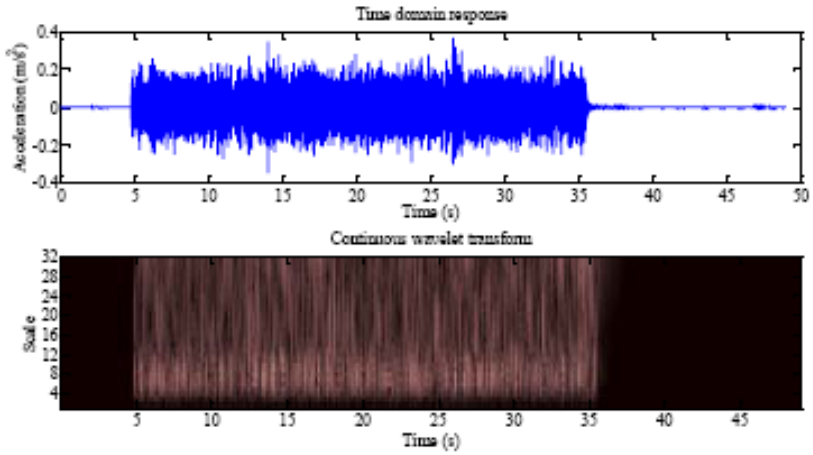
# Shear connector SC1 (near S1) loosen first and then SC16 (near S4)

S1-S4

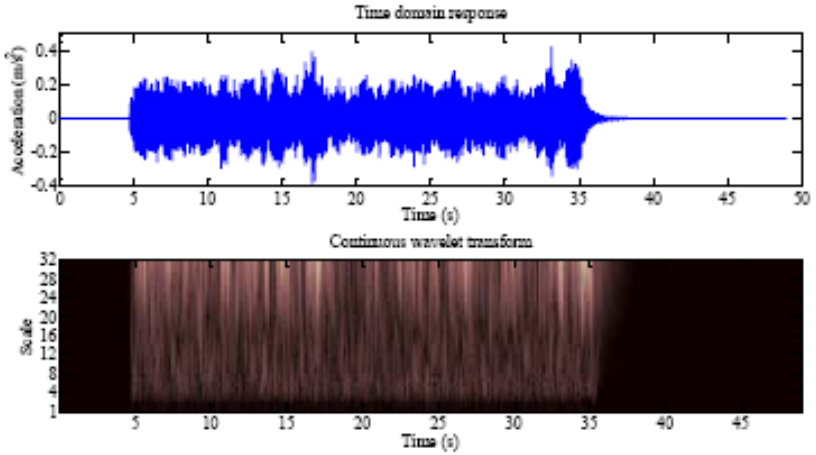



Detection results under white noise

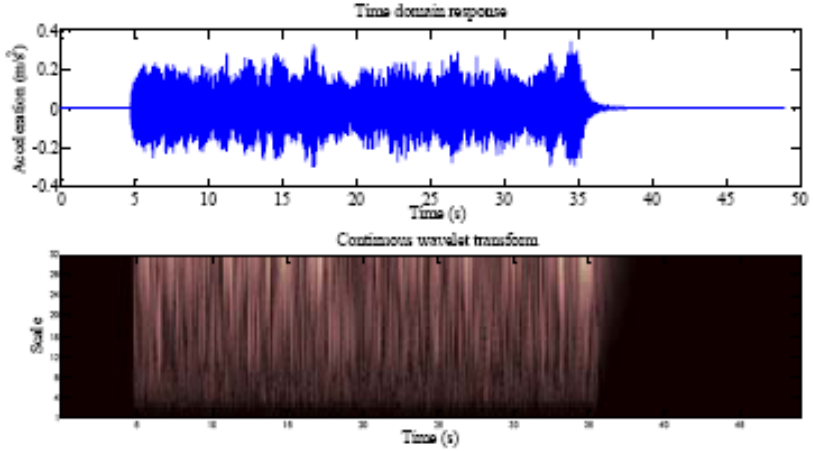
(a) A1



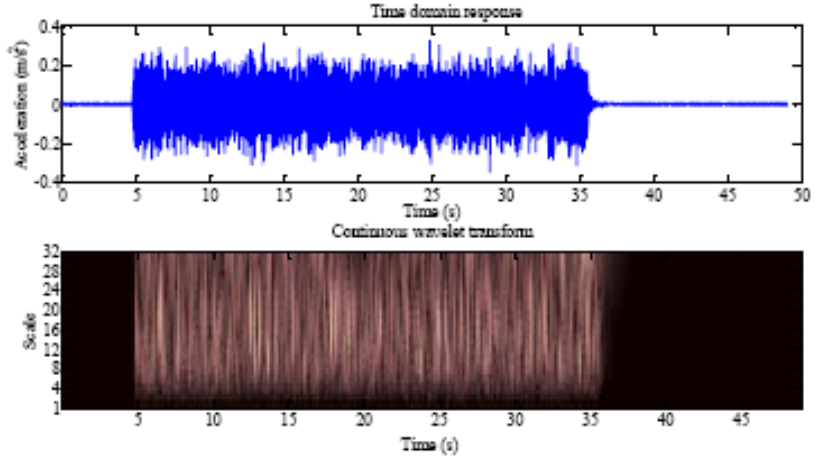

(b) A2




(c) A3




(d) A4



# Monitoring under moving traffic

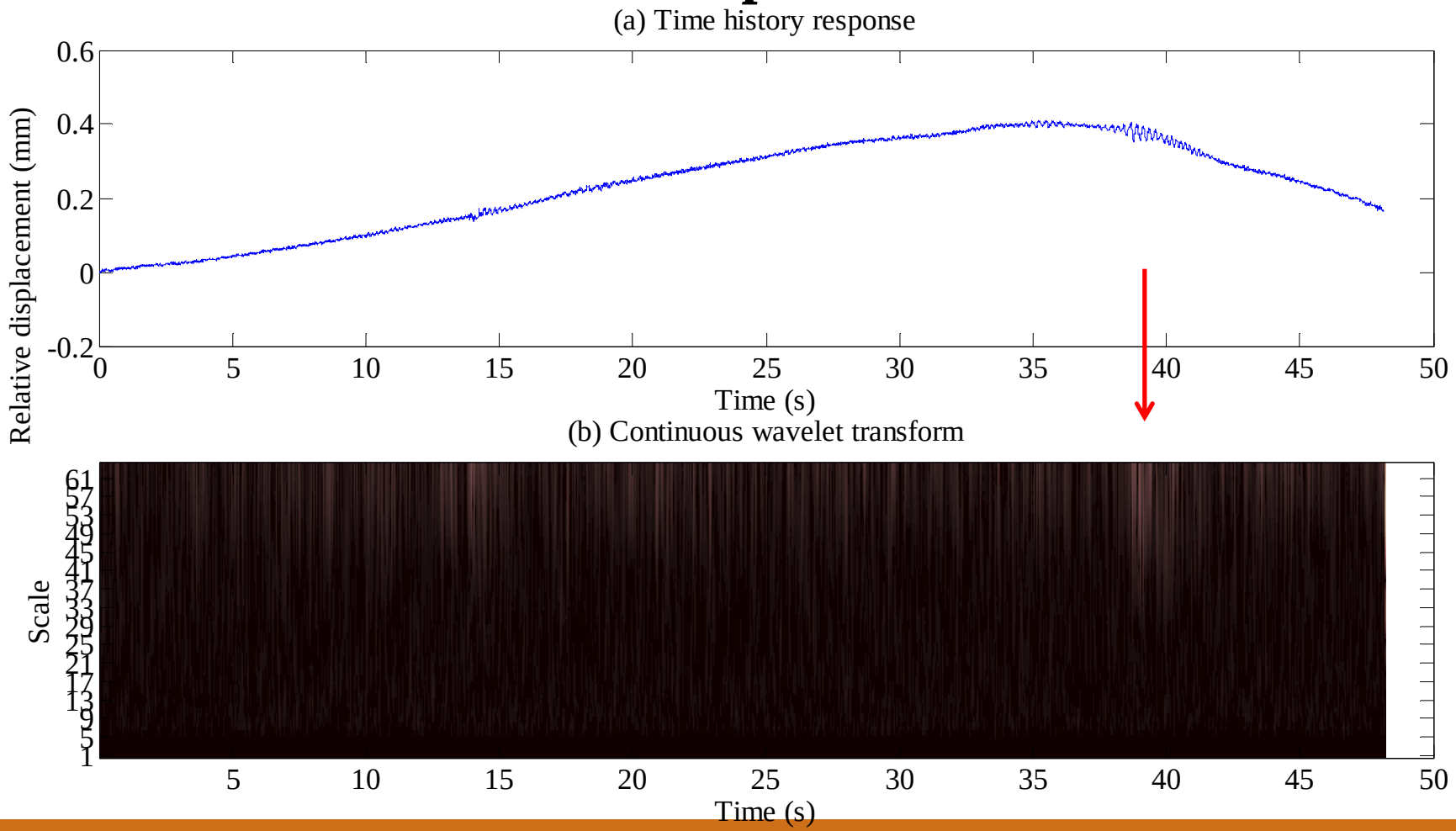
- 4 relative displacement sensors
- 4 accelerometers
- 3 LVDT sensors


# *Experimental Setup*

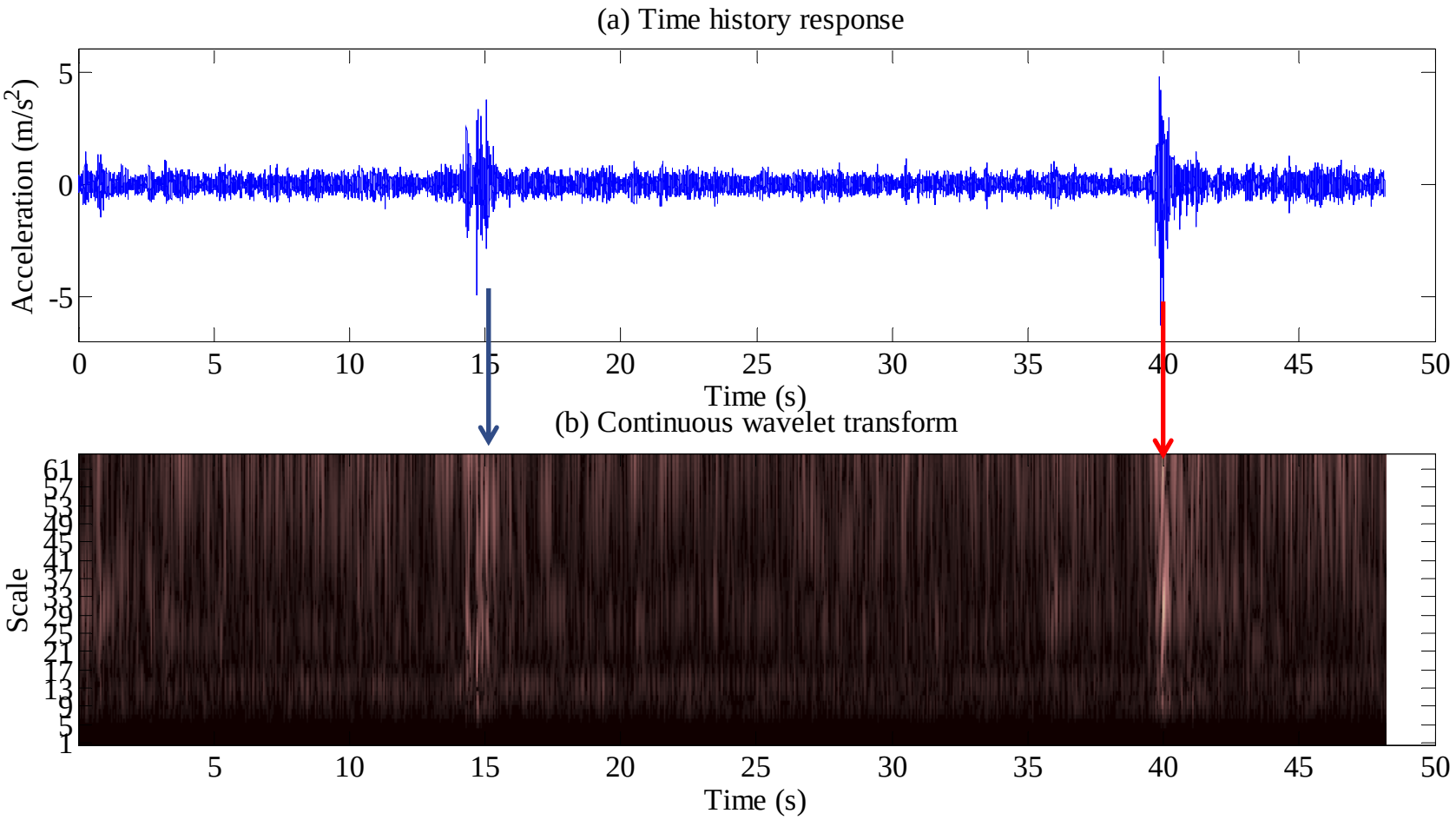
- Conducted the tests under undamaged and damaged state
- Travelling on the bridge with a constant speed
- Same travelling path by using a track

# Detection with data from damaged structure only

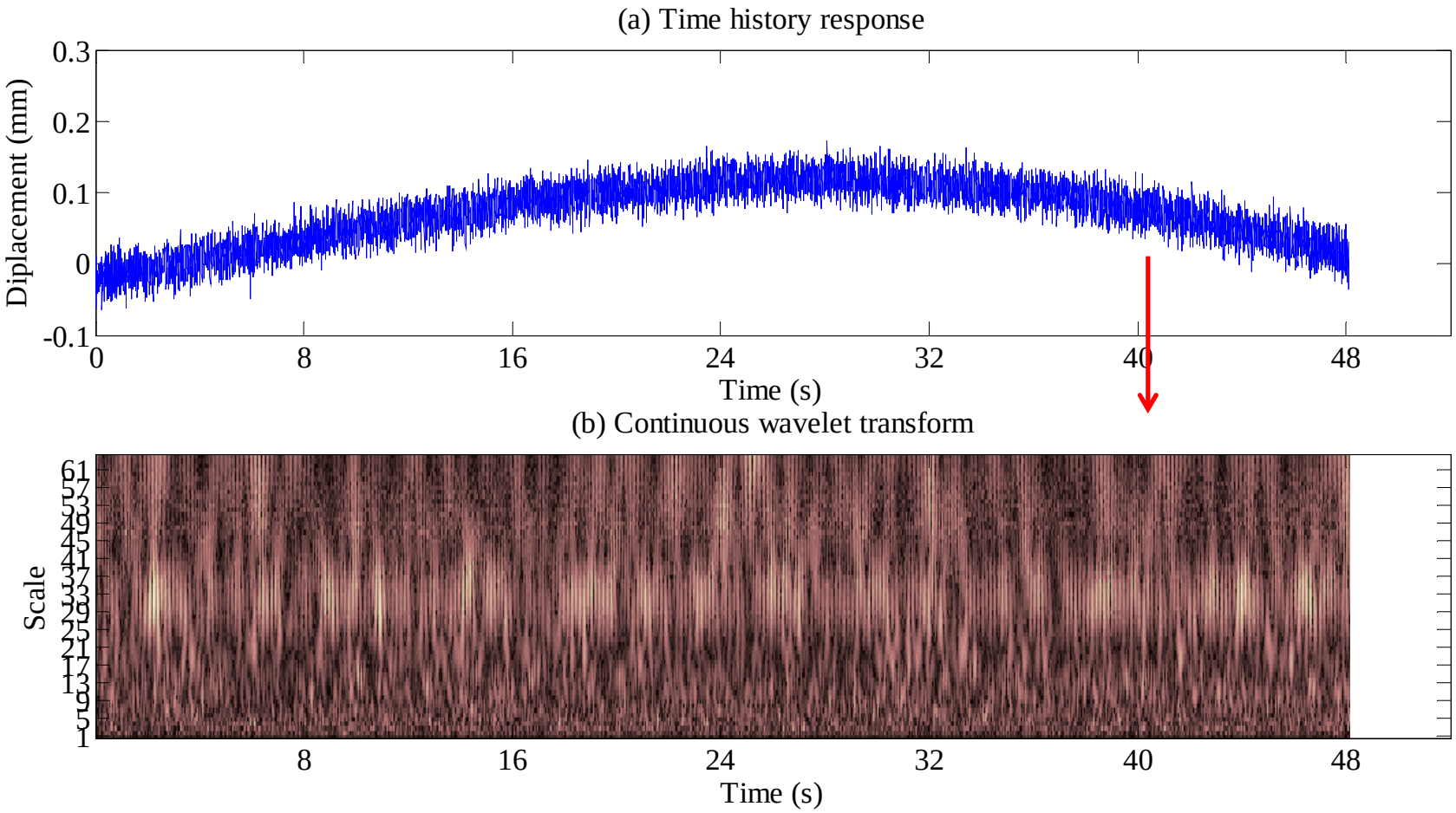
## *Relative displacement*



# Acceleration

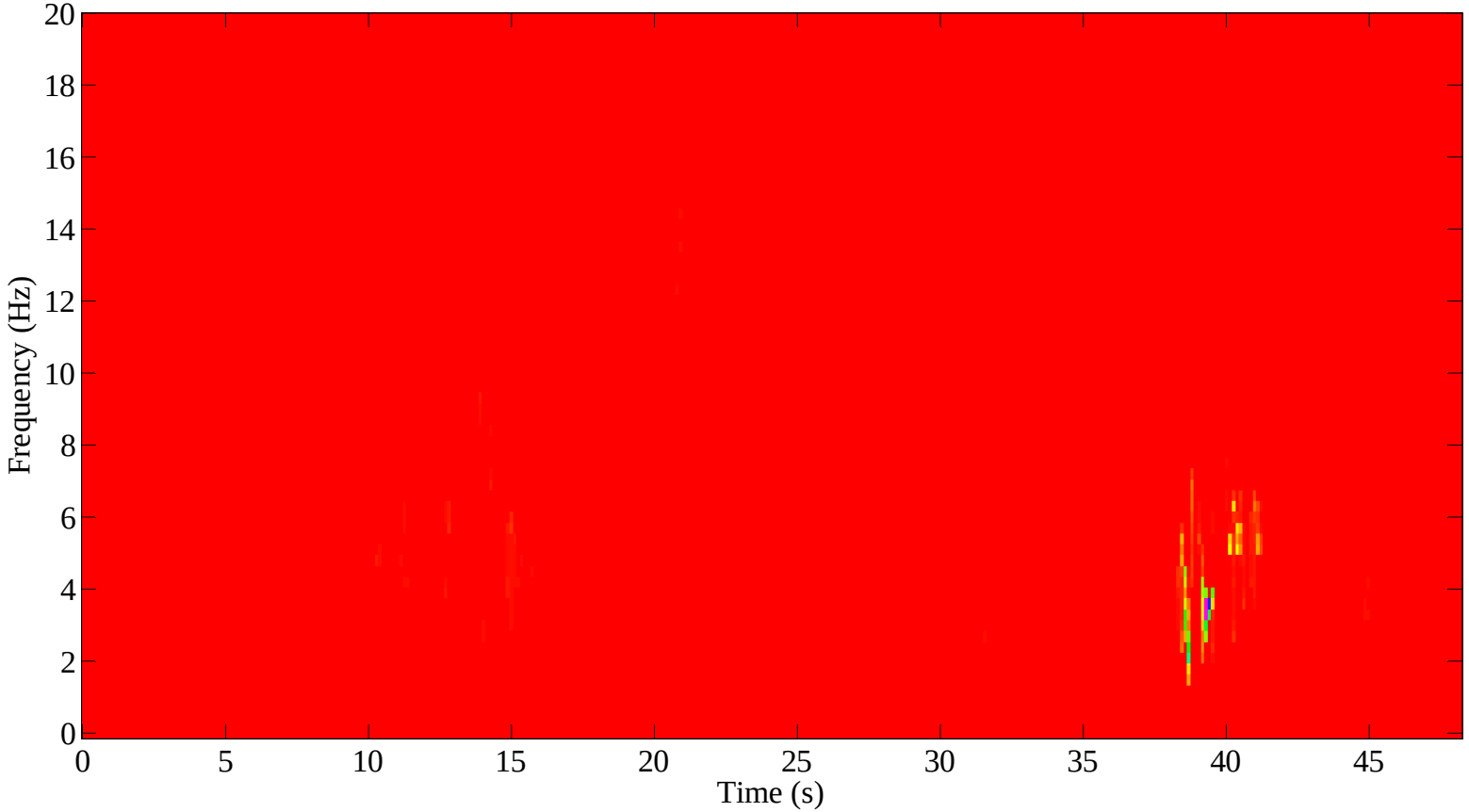


# *Displacement*

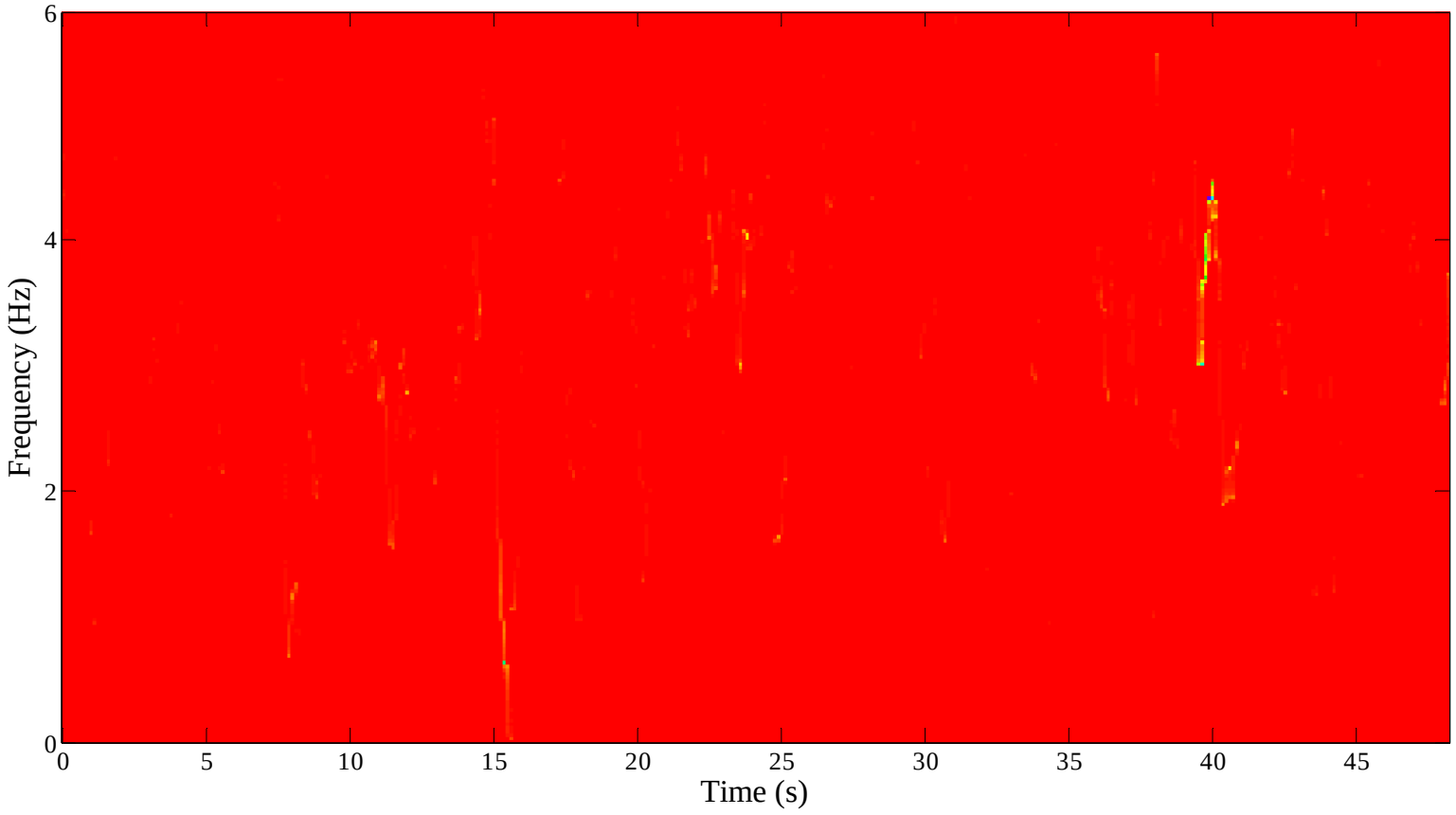


# Hilbert-Huang Transform

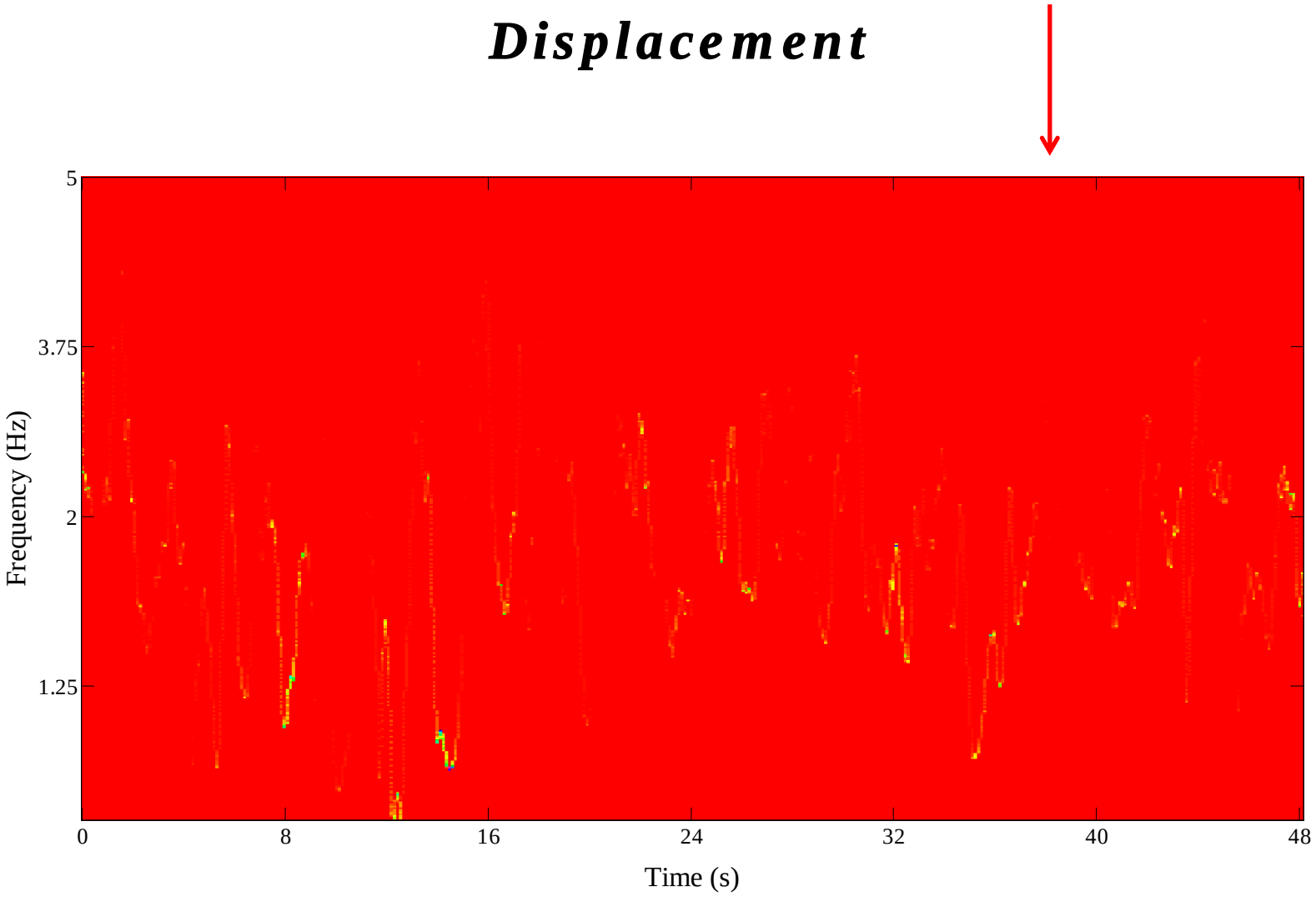
***Relative displacement***



# *Acceleration*



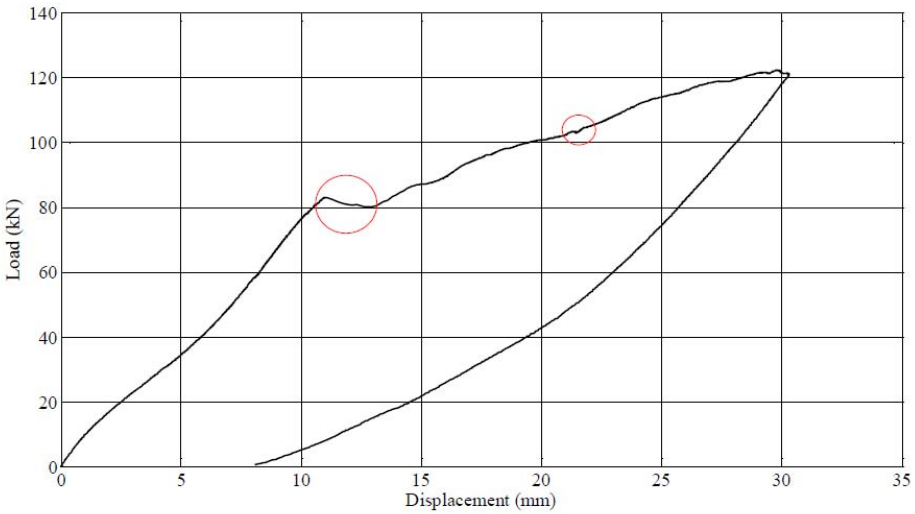
# *Displacement*



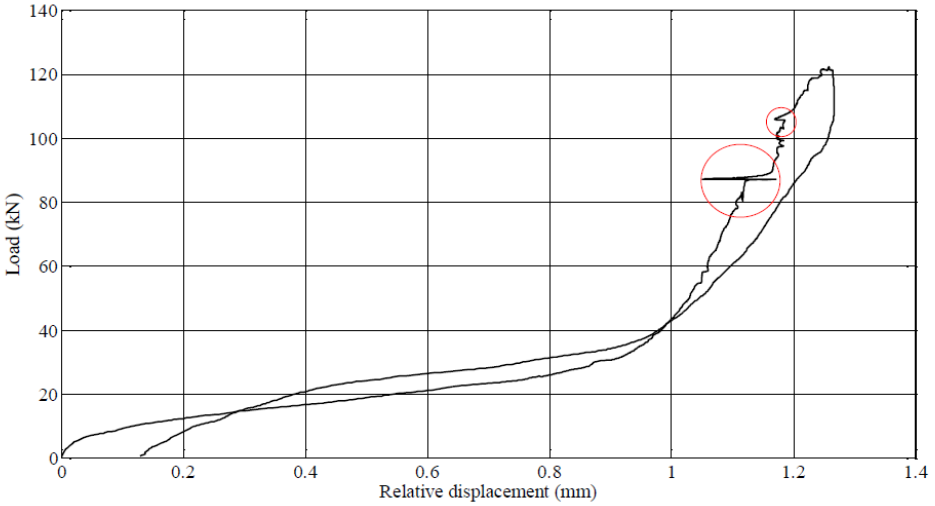
# Crack Identification

(a) First loading

(a) Displacement

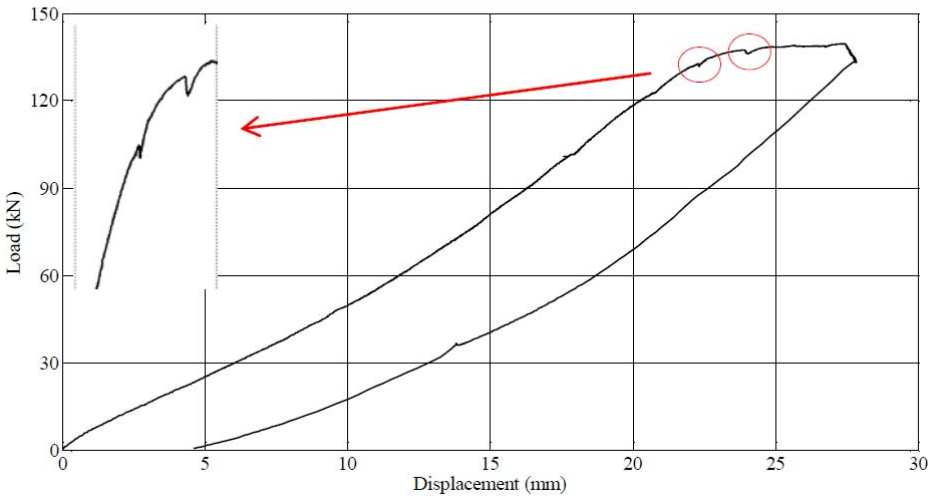



(b) Relative displacement

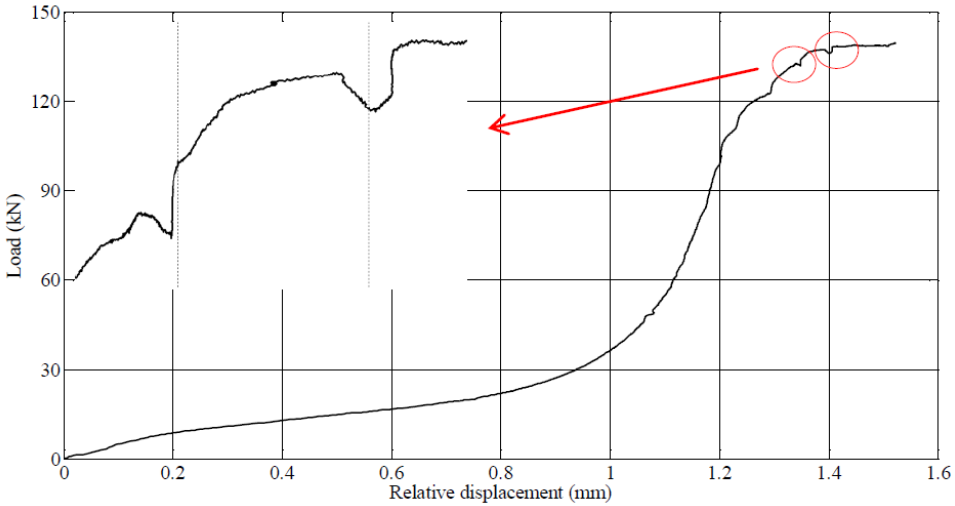



(b) Second loading

(a) Displacement




(b) Relative displacement




# Concluding remarks

- A relative displacement sensor is developed for condition monitoring of composite bridges under ambient and operational conditions
- The sensor is verified and sensitivity radius is investigated.
- Continuous wavelet transform and Hilbert-Huang transform have been used for the damage detection under traffic .
- Used to detect the crack occurrence.

# Acknowledgement


Cooperative Research Centre for
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Thank you for your attention!

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