

# ANCRiSST 2019 Procedia

## 14th International Workshop on Advanced Smart Materials and Smart Structures Technology

edited by

Vincenzo Gattulli, Oreste Bursi, Daniele Zonta





**A**NCRiSST 2019 Workshop, held in Rome on 18-21 July 2019, manifests a close collaboration between Europe, Asia and the Americas in the field of smart structures and materials. A year after the tragic collapse of the Morandi bridge in Genova and shortly after its demolition, the scientific discussion on novel solutions in structural health monitoring and control from an outstanding international scientific community is the catalyst for future headway in this field.

The ANCRiSST 2019 Procedia expresses current progress in smart materials and structures technology and is witness to ever growing international synergies among researchers. Emerging frontiers in automated inspection, sensing and control of civil infrastructure are focussed on. Six sections gather together contributions in smart materials for sensing and actuation, response prediction and evaluation, measurements and health monitoring, structural control, damage detection, mechatronics and automated inspection.

**Vincenzo Gattulli**, Department of Structural and Geotechnical Engineering, Sapienza University of Rome.

**Oreste Bursi**, Department of Civil, Environmental and Mechanical Engineering, University of Trento.

**Daniele Zonta**, Department of Civil and Environmental Engineering, University of Strathclyde.

ISBN 978-88-9377-114-6



9 788893 771146



[www.editricesapienza.it](http://www.editricesapienza.it)

Opera diffusa in modalità **open access**  
e sottoposta a licenza Creative Commons  
Attribuzione – Non commerciale  
Non opere derivate (CC BY-NC-ND), 3.0 Italia

Copyright © 2019

**Sapienza Università Editrice**  
Piazzale Aldo Moro 5 – 00185 Roma

[www.editricesapienza.it](http://www.editricesapienza.it)  
[editrice.sapienza@uniroma1.it](mailto:editrice.sapienza@uniroma1.it)

Iscrizione Registro Operatori Comunicazione n. 11420

ISBN 978-88-9377-114-6

DOI 10.13133/9788893771146

Pubblicato a luglio 2019



Quest'opera è distribuita  
con licenza Creative Commons 3.0  
diffusa in modalità *open access*.

In copertina: Colosseum Monitoring - Annamaria Pau

## TABLE OF CONTENTS

### Smart Materials for Sensing and Actuation

Graphene Sensing Meshes for Distributed Strain Field Monitoring <i>Sumit Gupta, Gianmarco Vella, Kenneth Loh and Anton Netachaev</i> .....	3
Active Metamaterial Skins for Actuation and Gripping <i>Yujin Park, Gianmarco Vella and Kenneth Loh</i> .....	7
Development of Automated Cable Tension Monitoring System Using Smart Sensors <i>Seunghoo Jeong, Hyunjun Kim, Junhwa Lee and Sung-Han Sim</i> .....	11
Voltammetric Sensor for Chloride Detection, Oxygen Availability and Humidity <i>Ana Martínez Ibernón, Josep Ramon Lliso Ferrando, Jose Manuel Gandia Romero, Juan Soto Camino and Isabel Gasch Molina</i> .....	15
Sensor Network for Structural Durability Control <i>Josep Ramon Lliso Ferrando, Ana Martínez Ibernón, Román Bataller Prats, José Enrique Ramón Zamora and Manuel Valcuende Payá</i> .....	19
Smart Kinesiology Tape for Human Physiological Monitoring <i>Yun-An Lin, Andrew Pedtke and Kenneth Loh</i> .....	23
Multi-Objective Optimization of Actuator and Sensor Location of Diagrid Structures Subjected to Earthquake Loading <i>Alejandro Palacio-Betancur and Mariantonietta Gutierrez Soto</i> .....	27

## Measurements and Health Monitoring

Inspection of Wire Breaks in Stay Cables or Post-Tension Tendons <i>Stephane Joye and Quentin Common .....</i>	33
Real Time Detection of Wire Failure in Stay Cables Or Post-Tension Tendons <i>Stephane Joye and Quentin Common .....</i>	37
Experimental Model Updating of a Full-Scale Concrete Frame Structure <i>Xi Liu, Xinjun Dong, R. L. Muhanna and F. Fedele .....</i>	41
Bayesian Forecasting Approach for Structure Response Prediction qnd Load Effect Separation of a Revolving Auditorium <i>Zhi Ma, Chungbang Yun and Yaozhi Luo .....</i>	45
Rail-strain-based Identification of Freight Train Loads <i>Annamaria Pau and Fabrizio Vestroni .....</i>	49
Influence of Directionality of Bi-Directional Ground Motions on Seismic Behavior of Bridge Bearings <i>Xinhao He and Akira Igarashi .....</i>	53
Monitoring-Driven Seismic Assessment of Existing Masonry Buildings <i>Panagiotis Martakis, Y. Reuland, Vasileios Dertimanis, Eleni Chatzi and P. Lestuzzi .....</i>	57
A Spectral Peak-Picking Method for On-board Operational Modal Analysis of Multi-type Vibration-based SHM <i>Federica Zonzini, Michelangelo Maria Malatesta, Denis Bogomolov, Nicola Testoni, Luca De Marchi and Alessandro Marzani .....</i>	61
Vibration data processing to assess the rigidity of diaphragms in existing buildings <i>Daniele Sivori, Marco Lepidi and Serena Cattari .....</i>	65
Measuring Total Transverse Displacement of Railroad Bridges Using Lasers and Vision-Based Structural Health Monitoring (SHM) on Unmanned Aerial Systems (UAS) <i>Xinixing Yuan, Roya Nasimi and Fernando Moreu .....</i>	69

## Table of contents

Nontarget-based Displacement Measurement Using Combined RGB-D Information <i>Sahyeon Lee, Junhwa Lee, Jong-Woong Park and Sung-Han Sim .....</i>	73
Study of an Optimal Command Law Combining Weather Forecast and Energy Reduction for Transport Structure Surface De-Icing by Joule Effect <i>Nicolas Le Touz and Jean Dumoulin .....</i>	77
Measurement of Deflection of Concrete Beam Strengthened with UV-Cured Glass-Fiber Reinforced Polymer Using a Computer Vision Method <i>Baohua Shan, Yu Shen, Xianxing Su and Guijun Xian .....</i>	81
New Solutions of Sensors and Instrumentation For Dynamic monitoring of Civil Structures: ViBest/FEUP experience <i>Carlos Moutinho and Álvaro Cunha .....</i>	85
Uncooled infrared thermal camera for thermal monitoring or Non-Destructive Testing of Civil Engineering structures <i>Jean Dumoulin .....</i>	89
Structural Health Monitoring Using a Generative Model <i>Yi-Qing Ni, Yi Gong and Yuan-Hao Wei .....</i>	93
Hand phones, handy sensors: walking-induced vibration testing of slab floors assisted by mobile phone recordings <i>Marcello Catena, Bruno Alberto Dal Lago, Francesco Foti and Luca Martinelli .....</i>	97
Application of Ultrasonic Guided Waves Technology to Inspection of Bolt Group Joints <i>Yue Zhang and Dongsheng Li .....</i>	101
IoT Based Monitoring and Assessment System for Construction-induced Vibration <i>Qiuhan Meng and Songye Zhu .....</i>	105

## Response Prediction and Evaluation

Structural Reliability Calculation Method Based on Deep Reinforcement Learning <i>Yuequan Bao, Zhengliang Xiang, Zhiyi Tang and Hui Li .....</i>	111
A Probabilistic Analysis of the Wind Field at Sulafjorden Bridge Site <i>Dario Fernandez Castellon, Aksel Fenerci and Ole Øiseth .....</i>	115
Research Project Toward Enhancement of Resilience for Tokyo Metropolitan Area: Preparing for Severe Seismic Event in Tokyo <i>Akira Nishitani, Koichi Kajiwara, Takuya Nagae, Takahito Inoue, Koichi Kusunoki, Izumi Nakamura, Masahiro Kurata, Yohsuke Kawamata, Eiji Sato, Kazuhiro Hayashi, Takeshi Morii, Rie Okazawa, Keiichi Okada and Michihito Shiraishi .....</i>	119
Experimental investigation on the ball drop impact resistance of traditional glass windows <i>Lucia Figuli, Chiara Bedon, Daniel Papán and Zuzana Papanova .....</i>	123
A New Approach for Probability Distribution Estimation of Seismic Response in Structures with Nonlinear Shear Wall Behavior <i>Heekun Ju, Seung-Seop Jin and Hyung-Jo Jung .....</i>	127
Proposal for the definition of the attention level classification of bridges <i>Giovanni Buratti, Antonella Cosentino, Francesco Morelli and Walter Salvatore .....</i>	131
Calibration of a structural health monitoring system for multiple base-isolated structures using the dynamic response <i>Paolo Di Mascio, Francesco Potenza and Vincenzo Gattulli .....</i>	135
Dynamic Identification on an Ancient Steel Bridge of Six Spans <i>Salvador Ivorra, Manuel Buitrago, Elisa Bertolesi , Benjamín Torres and David Bru .....</i>	139
Computer-Aided Seismic Reliability Analysis of Critical Infrastructure: Smart Water Network <i>Sungsik Yoon, Hyung-Jo Jung and Young-Joo Lee .....</i>	143

## Damage Detection

Guided Waves Approach for Monitoring Weld Zone In an I-shape Steel Beam <i>Jia-Qi Tu, Chung-Bang Yun, Xian Xu, Zhi-Feng Tang and Jian-Jun Wu</i> .....	149
Guided Wave Method for Tension Monitoring and Damage Detection in a Cable <i>Xiaodong Sui, Yuanfeng Duan, Chungbang Yun, Zhifeng Tang and Pengfei Zhang</i> .....	153
Damage detection of non-linear reinforced concrete structure by means of single sensing node <i>Said Quqa, Luca Landi and Pier Paolo Diotallevi</i> .....	157
A statistically based method for the selection of sensors networks in dynamic damage detection of beams <i>Egidio Lofrano, Achille Paolone, Marco Pingaro and Patrizia Trovalusci</i> .....	161
Automated Structural Damage Detection for a Simple Beam Structure using Deep Convolutional LSTM <i>Jongbin Won and Jongwoong Park</i> .....	165
Dynamics and damage sensitivity of Quisi steel truss bridge <i>Marianna Cognale, Vincenzo Gattulli, Salvador Ivorra and Francesco Potenza</i> .....	169
Vibration-based Damage Identification in the UHPFRC Strengthened Buna Bridge <i>Henar Martin-Sanz, Konstantinos Tatsis, Domagoj Damjanovic, Aljosa Sajna, Irina Stipanovic, Uros Bohnic, Eugen Brühwiler and Eleni Chatzi</i> .....	173

## Structural Control

Passive control strategy for wind-induced parametric instabilities in suspension bridges

*Andrea Arena and Walter Lacarbonara* ..... 179

Investigation on Nonlinear Parametric Vibration Control of Stay Cable with Super-Long Span

*Min Liu, Ruiqian Long and Liangfu Zheng* ..... 183

Optimal Design of Linear and Nonlinear Seismic Isolation Systems for Fuel Storage Tanks based on Metamaterial Concepts

*Francesco Basone, Moritz Wenzel, Oreste Salvatore Bursi and Roberto Andreotti* ..... 187

Construction-Induced Vibration Impact Assessment and Mitigation for Hospital Redevelopment Project in Hong Kong

*Zimo Zhu, Shiguang Wang and Songye Zhu* ..... 191

Swing motion control of suspended structure by innovative Active Rotary Inertia Driver system

*Chunwei Zhang and Hao Wang* ..... 195

A Novel inerto-viscous damper for seismic vibration control

*Mahdi Abdeddaim, Arnav Anuj Kasar, Nassim Djedoui and Abdelhafid Ounis* ..... 199

Topology Optimization Design of Seismically Excited Structures with Dampers

*Fernando Gomez and Billie Spencer* ..... 203

Numerical Investigation of a new hybrid electromagnetic damper for reducing cable vibration

*Seungkyung Kye, Hyung-Soo Kim and Hyung-Jo Jung* ..... 207

Experimental Investigation on Inertial Mass Damper for Cable Vibration Mitigation

*Shenghao Dong, Yuanfeng Duan, Chungbang Yun and Hongmei Zhang* ..... 211

## Mechatronics and Automated Inspections

Vision-based bridge component recognition and position estimation toward rapid automated inspection <i>Yasutaka Narazaki, Vedhus Hoskere and Billie F. Spencer</i>	217
A Study of FLC Application for Robot Manipulator Suspended from Crane Hoist Model <i>Cheng Peng, Yi Jiang and Jiansong Zhang</i>	221
Damage Detection of Vision-based Bridge Inspection System using Unmanned Aerial Vehicle <i>Jin-Hwan Lee, Sung-Sik Yoon, Jong-Woong Park and Hyung-Jo Jung</i>	225
Design and simulation of a wall-climbing drone for bridge inspection <i>Marco Romano, Erika Ottaviano, Antonio Gonzalez-Rodriguez, Fernando J. Castillo-Garcia and David Rodriguez-Rosa</i>	229
Augmented Reality Interface with Strain Gauge Sensors for Railroad Bridge Inspections <i>Marlon Agüero, Dilendra Maharjan, Maria Del Pilar Rodriguez and Fernando Moreu</i>	233
Enterprises and Drones: new systems for Drone Operations Management <i>Chiara Mozzetti, Alberto De Vitis, Daniele Spigarelli and Giorgio Nobby Raganelli</i>	237
New Cable Climbing Robot for Automated Inspection of Cables of Suspension Bridges <i>Sergio Juarez-Perez, Erika Ottaviano, David Rodriguez-Rosa, Antonio Gonzalez-Rodriguez and Fernando Castillo-Garcia</i>	241
Inspection and monitoring by enhanced mechatronic solutions in the Gran Sasso National Laboratories <i>Cecilia Rinaldi, Umberto Di Sabatino, Francesco Potenza and Vincenzo Gattulli</i>	245
New Magnetic Climbing Robot for Automated Inspection of Steel Structures <i>David Rodriguez-Rosa, Guillermo Rubio-Gomez, Erika Ottaviano, Antonio Gonzalez-Rodriguez and Fernando Castillo-Garcia</i>	249
Automatic vehicle passage detection using wireless accelerometers toward Bridge Weigh-In-Motion <i>Tomonori Nagayama, So Kato, Haoqi Wang and Mayuko Nishio</i>	253