JSPS postdoctoral fellowship 2019

at Tohoku University, Sendai,

Fibre reinforced Self-Healing materials (FISH project)

Dr Riccardo Maddalena
Cardiff University, UK

JSPS London
Pre-departure Seminar
London
17th October 2019

The speaker
Riccardo Maddalena

- Current: Research Associate and Project Manager at **Cardiff University** – UK

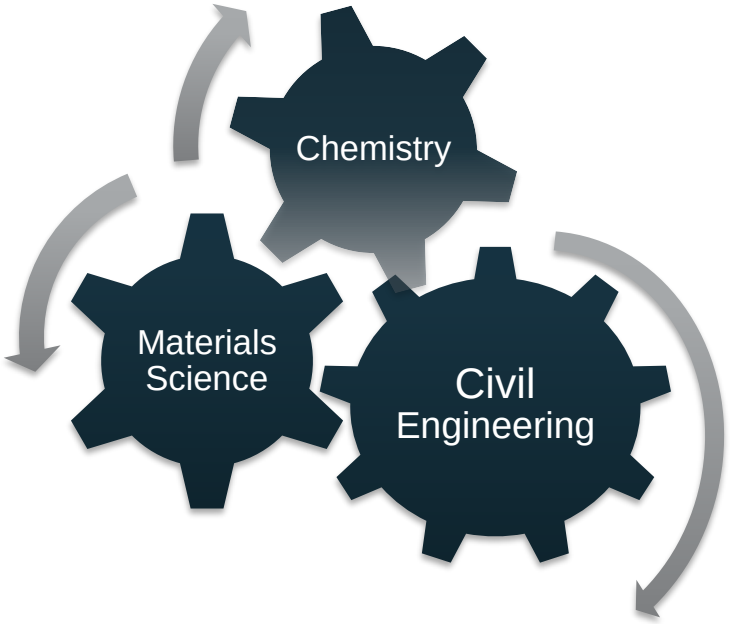
- PhD in Civil and Environmental Engineering **University** of **Strathclyde** – UK
- BEng and MEng in Civil and Environmental Engineering, **Catania University** – IT

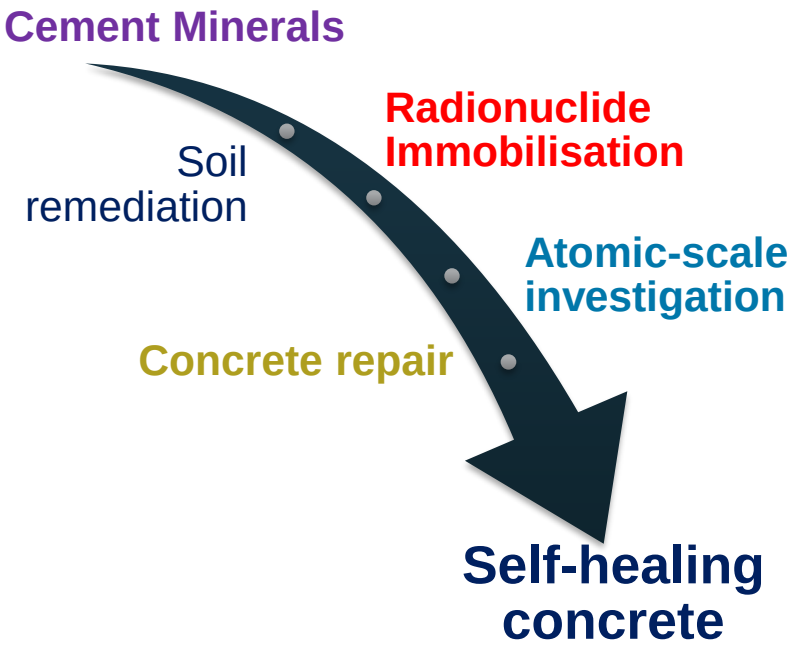
- Akebono Brake Industry Co. Ltd – Hanyu, Japan
- Technoside Srl - Italy

- **JSPS** Postdoctoral Fellow at **Tohoku University** – Japan, 2019
- Visiting Researcher at University of Strathclyde – UK, 2017-2018
- Visiting researcher at Tsinghua University – China, 2017
- European Project 'Vulcanus in Japan', 2009-2010

SICILIAE STVDIVM GENERALE 1434 University of Catania
akebono
TOHOKU UNIVERSITY
ヴルカヌス Vulcanus in Japan
CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD
清華大學 Tsinghua University
University of Strathclyde Engineering
日本学術振興会 Japan Society for the Promotion of Science
RESILIENTMATERIALS4LIFE

Research interests and collaborations





Introduction

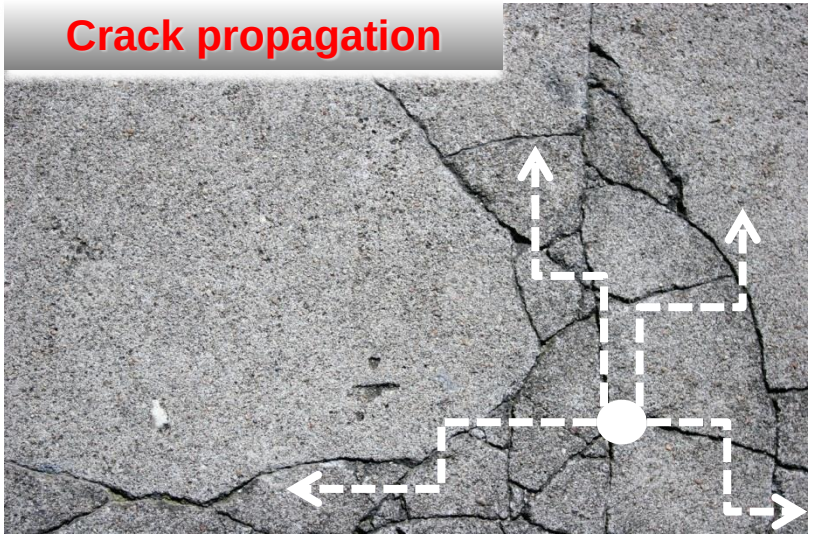
Deterioration of concrete and its durability has been the main concern in the last decades

[J. Collins 2010 - www.bridgehunter.com]

[Engineering and Technical Consultants, 2010]

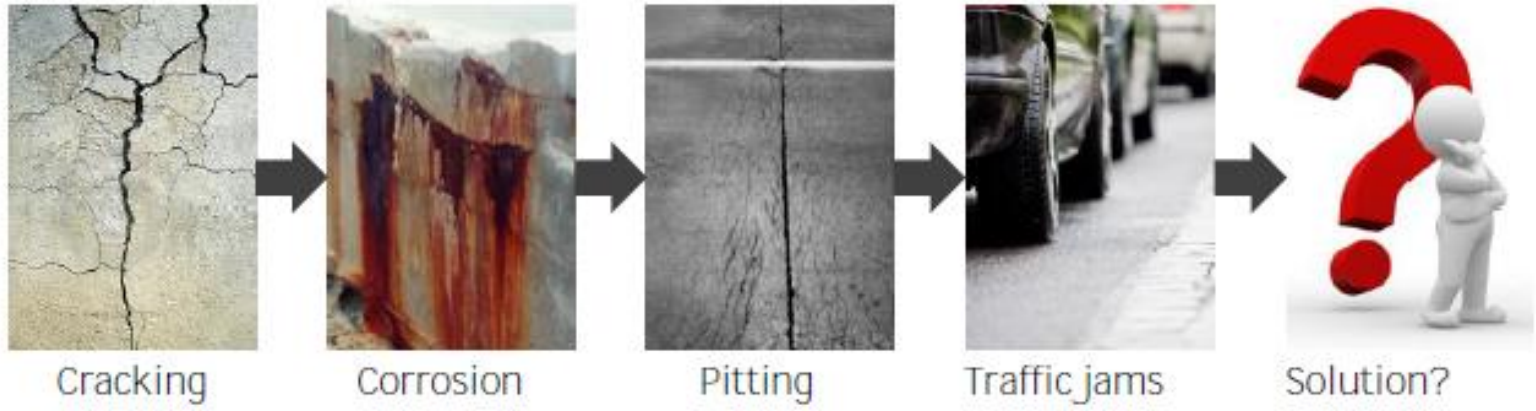
Introduction

- Chemical attack due to chlorides or other corrosive compounds
- Freeze and thaw cycles exposition
- Erosion due to saline environment
- High moisture transport through concrete elements



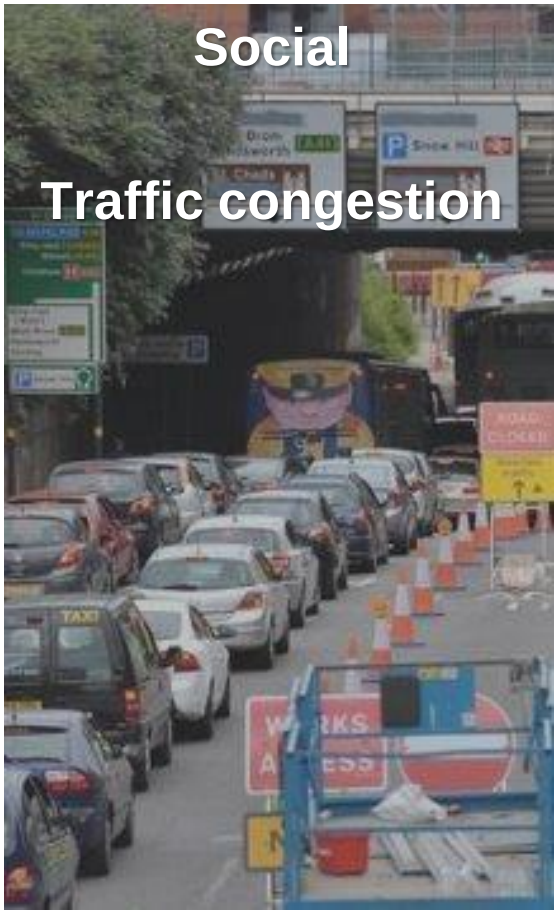
The main effect is the formation of nano-micro-macro-**dangerous** cracks. Those can in turn involve several reactions, increasing the moisture content, air entrainment, contamination flux and compromise the safety, standard conformity and workability of the concrete structures.

Introduction



Source: D. Snoeck, 2015

Some statistics



10% UK traffic congestion

Over 6,500 bridges in Japan in need of repair

5-7% global CO_2 emissions

Cost

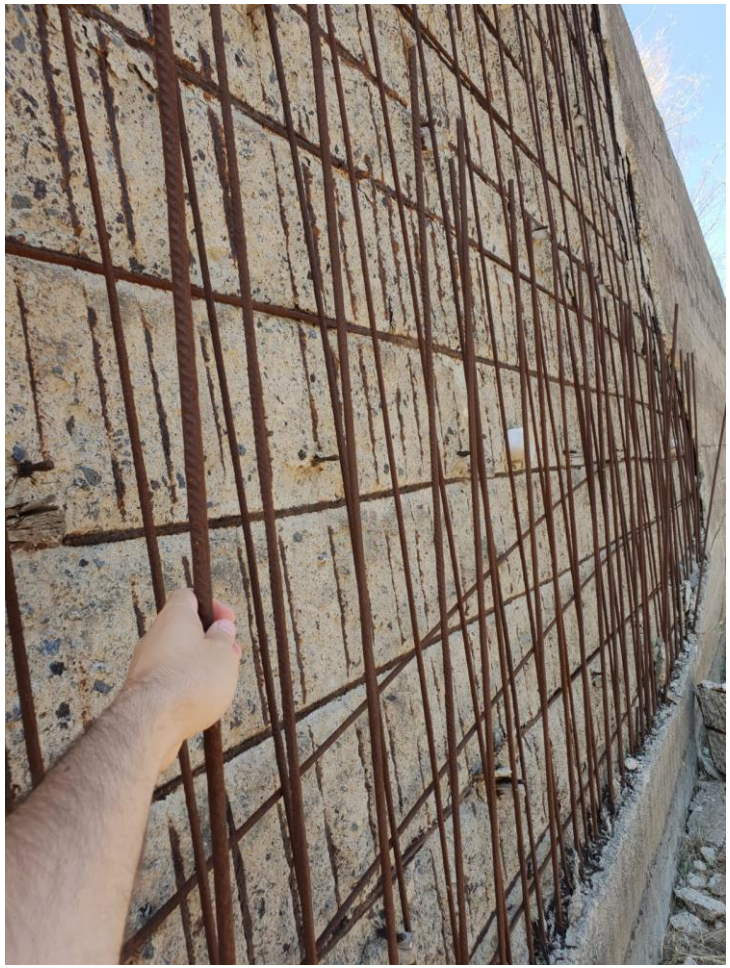
£50 bn /year in UK

¥1 bn/year in Japan

Looking at the real world

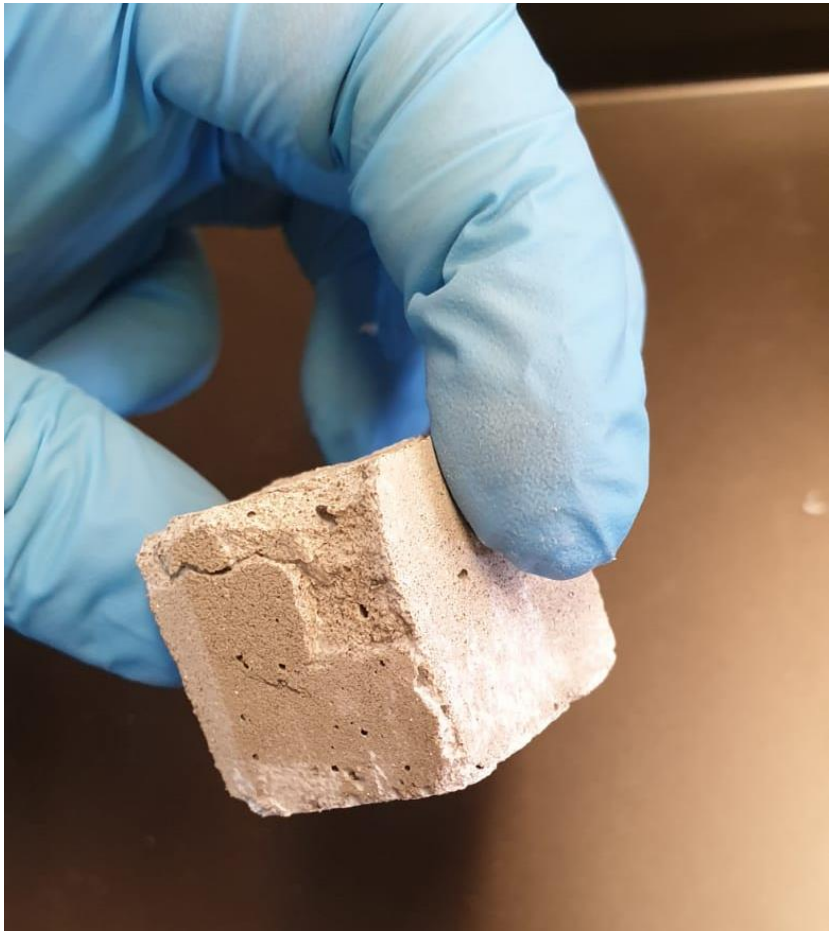
[R. Maddalena, 2018 – Retaining wall, SS560, ITALY]

Concrete damage of the reinforcement cover layer can lead to rebar corrosion and sub sequential loss in strength and collapse of the structure.



Looking at the real world

[R. Maddalena, 2018 – Building materials subject to freeze/thaw cycles, ITALY]



[R. Maddalena, 2019 – Cement mortar subject to freeze cycles]

Looking at the real world

[R. Maddalena, 2018 – Dam for electricity production, Skopje, FYR MACEDONIA]

Inspection and maintenance is not always straightforward.
The internal wall structure of a dam, or oil-extraction wells are examples challenges for inspection to detect damage and cracks in inaccessible areas.

[source: www.vangardngr.com]

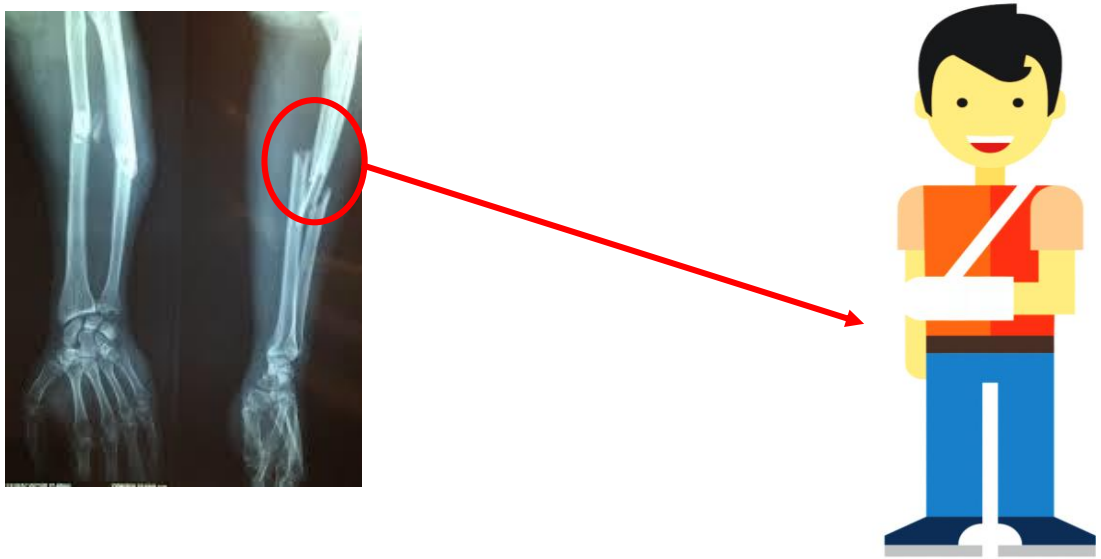
Looking at the real world

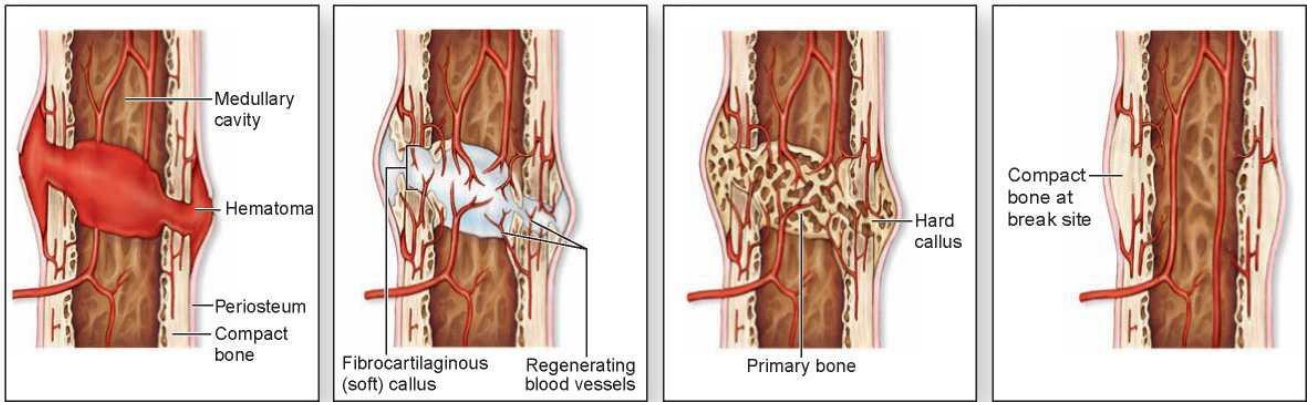
[R. Maddalena, 2019 – Prefabricated concrete beams, damaged during handling, Sendai, JAPAN]

Looking at the real world

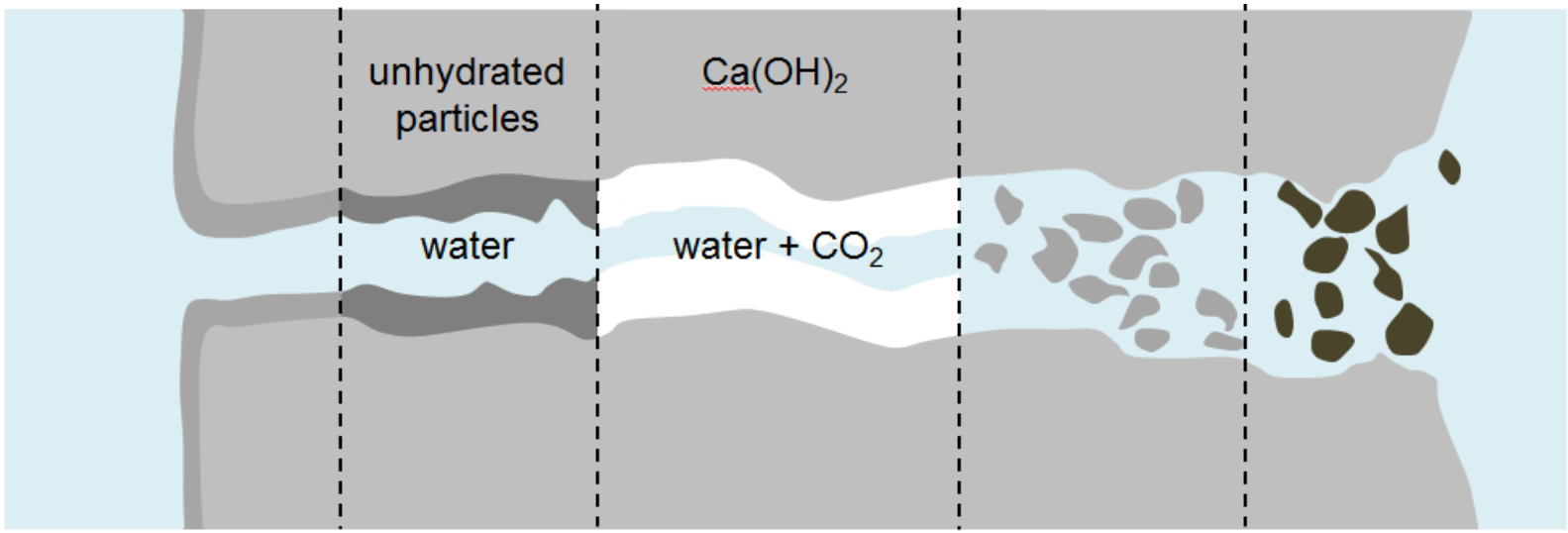
[R. Maddalena, 2019 – Under passage, Sendai, JAPAN]

Healing process in human body



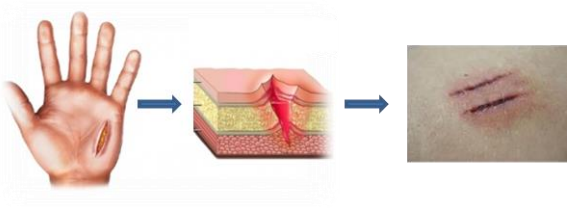


Healing process in building materials



Biomimetic materials

- ✓ Inspiration from natural/biological systems
- ✓ Ability to adapt and respond to their environment



- ✓ Potential infrastructure materials that self-sense & self-repair
- ✓ Slowest sector to adopt/adapt new technologies
- ✓ Construction materials perceived as cheap and straightforward
- ✓ Cutting-edge material technologies not justified

- ✓ Biomimetic Materials significant role to play in our future infrastructure
- ✓ Paradigm change in way we approach design & performance of our infrastructure

RESILIENTMATERIALS4LIFE

EPSRC
Pioneering research and skills

4 universities

over **30** researchers

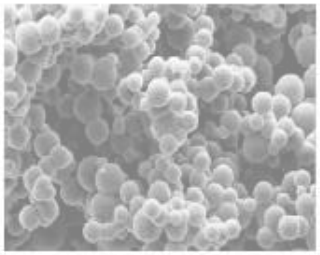
over **10** industrial partners

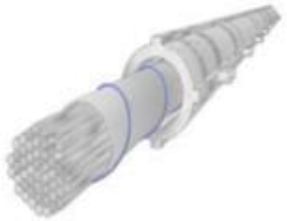
Materials, Engineering, Biology, Chemistry, Polymers, Mechanics, Numerical Modelling

2017 - 2022

Biomimetic technologies

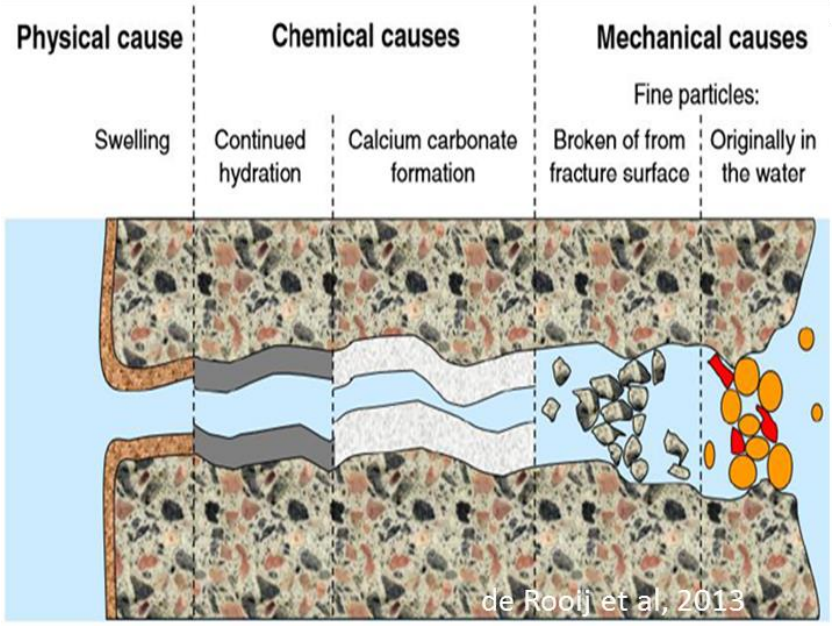
- Bacteria
- Microcapsules
- Shape Memory Polymers
- Vascular Flow Network
- Smart Sensor
- Modelling



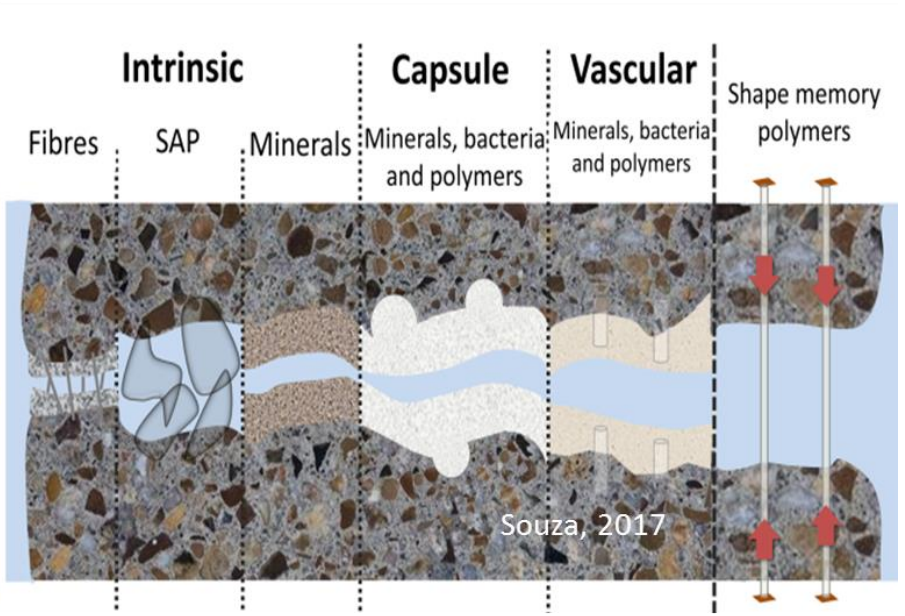



Self-Healing in Cementitious Systems

Autogenic <150µm



Autonomic >150µm



Research at Tohoku University

FISH project

Life Cycle Engineering (**LCE**) Laboratory
Graduate School of Engineering and Architecture, Sendai
Prof Tomoya **Nishiwaki**
3 months

- Development of fibre reinforce cement with **self-healing** properties
- Assessing the self-healing capability (crack-closure) with different techniques
- Pioneering **Tera Hertz wave spectroscopy** for crack detection in building materials
- Assessing the **carbon footprint** of self-healing materials

Research at Tohoku University

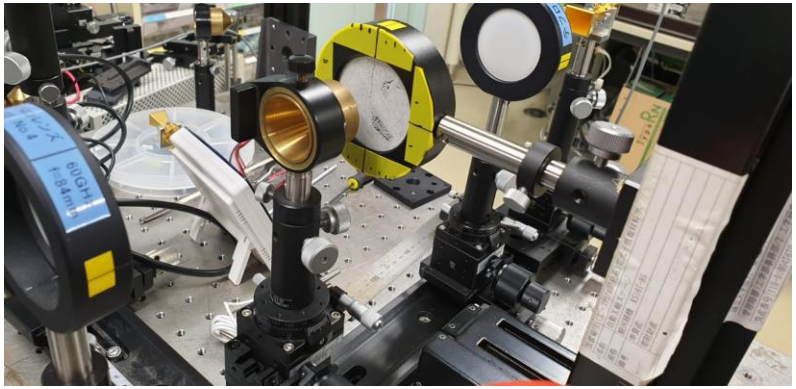
Sample preparation

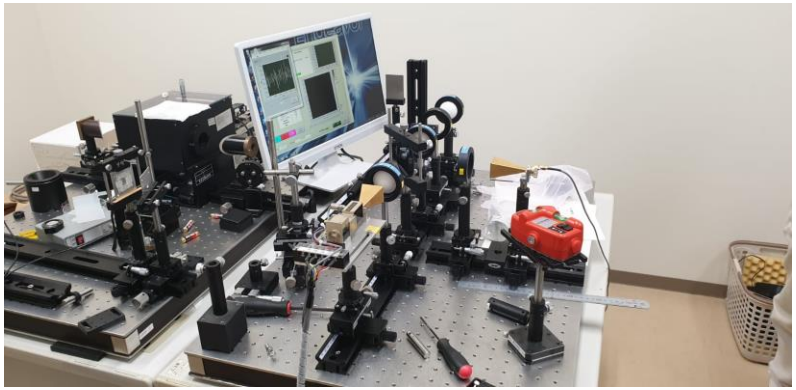
Incorporation of waste material

Research at Tohoku University

Research at Tohoku University

Self-healing measurements

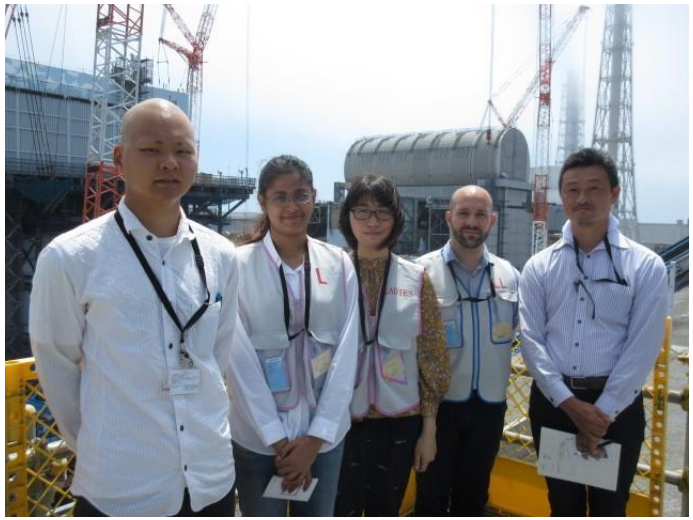




THz spectroscopy

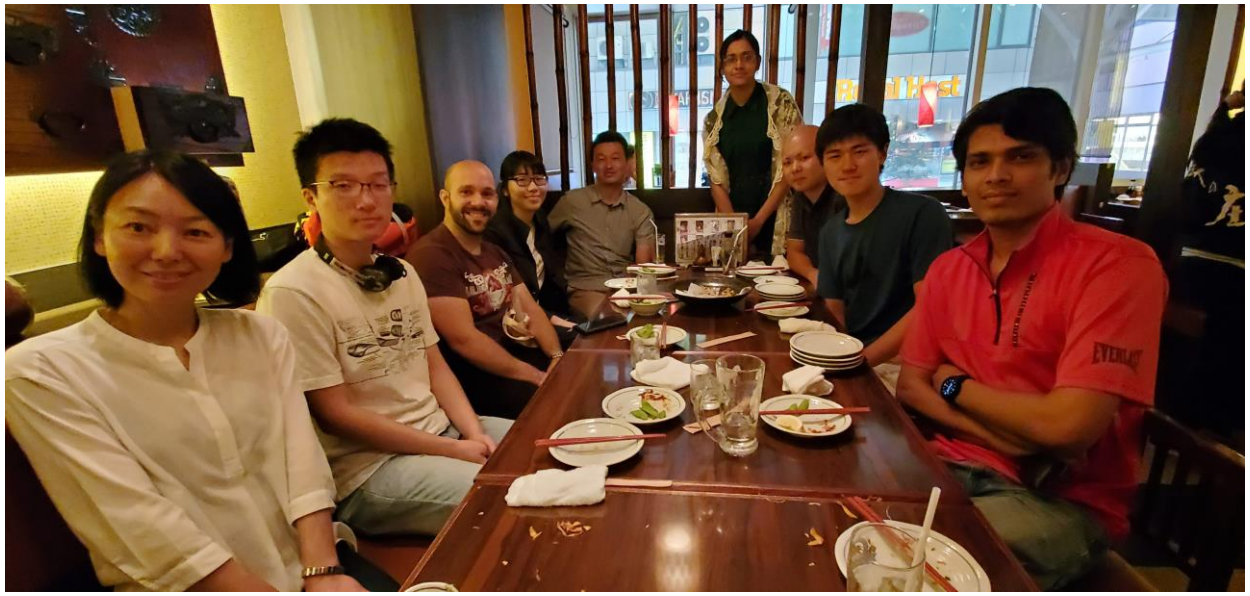
Research at Tohoku University

Site Visits



Life in Sendai and Japan

LCE Group

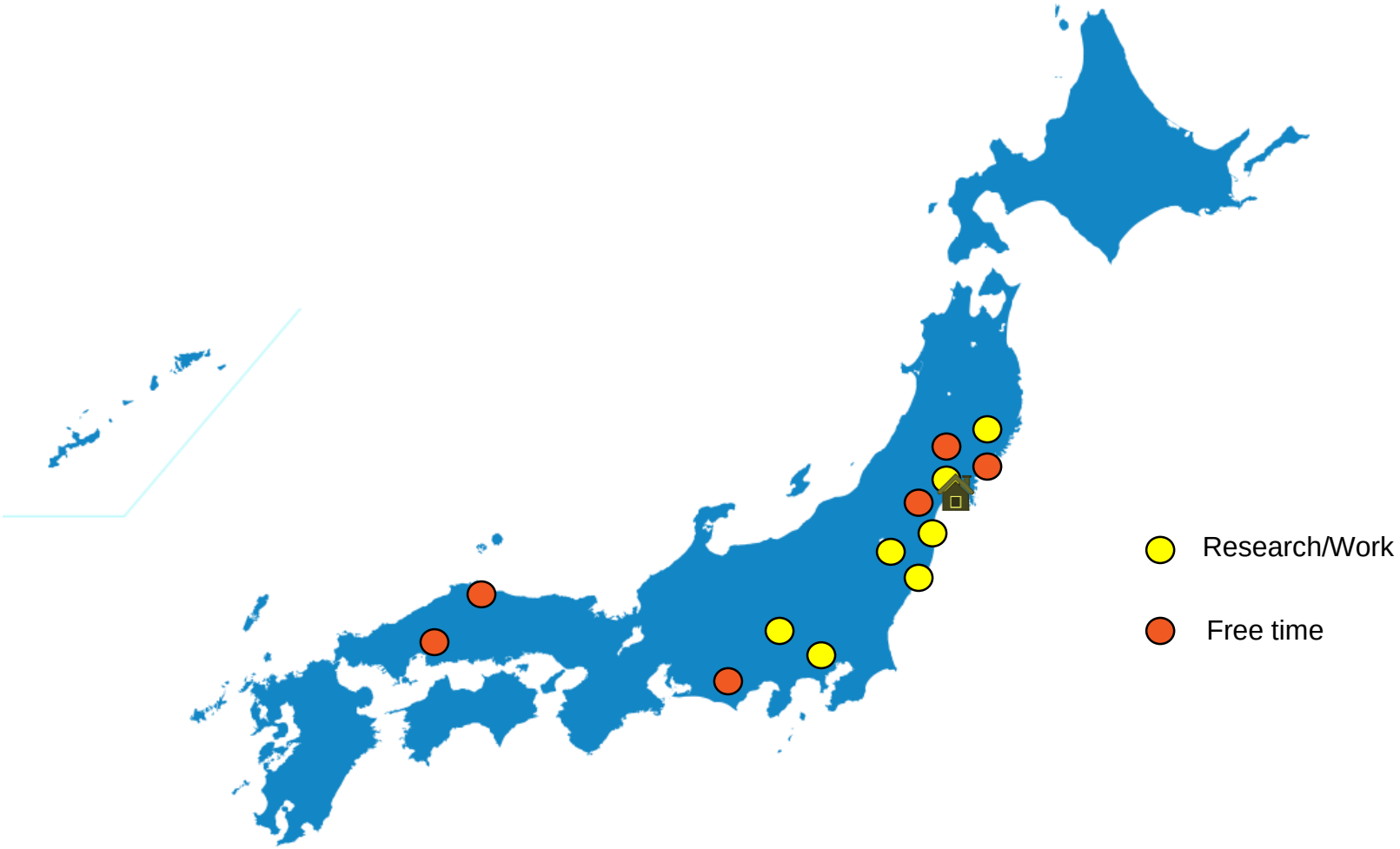


Life in Sendai and Japan

Sendai

Kyoto & Hiroshima

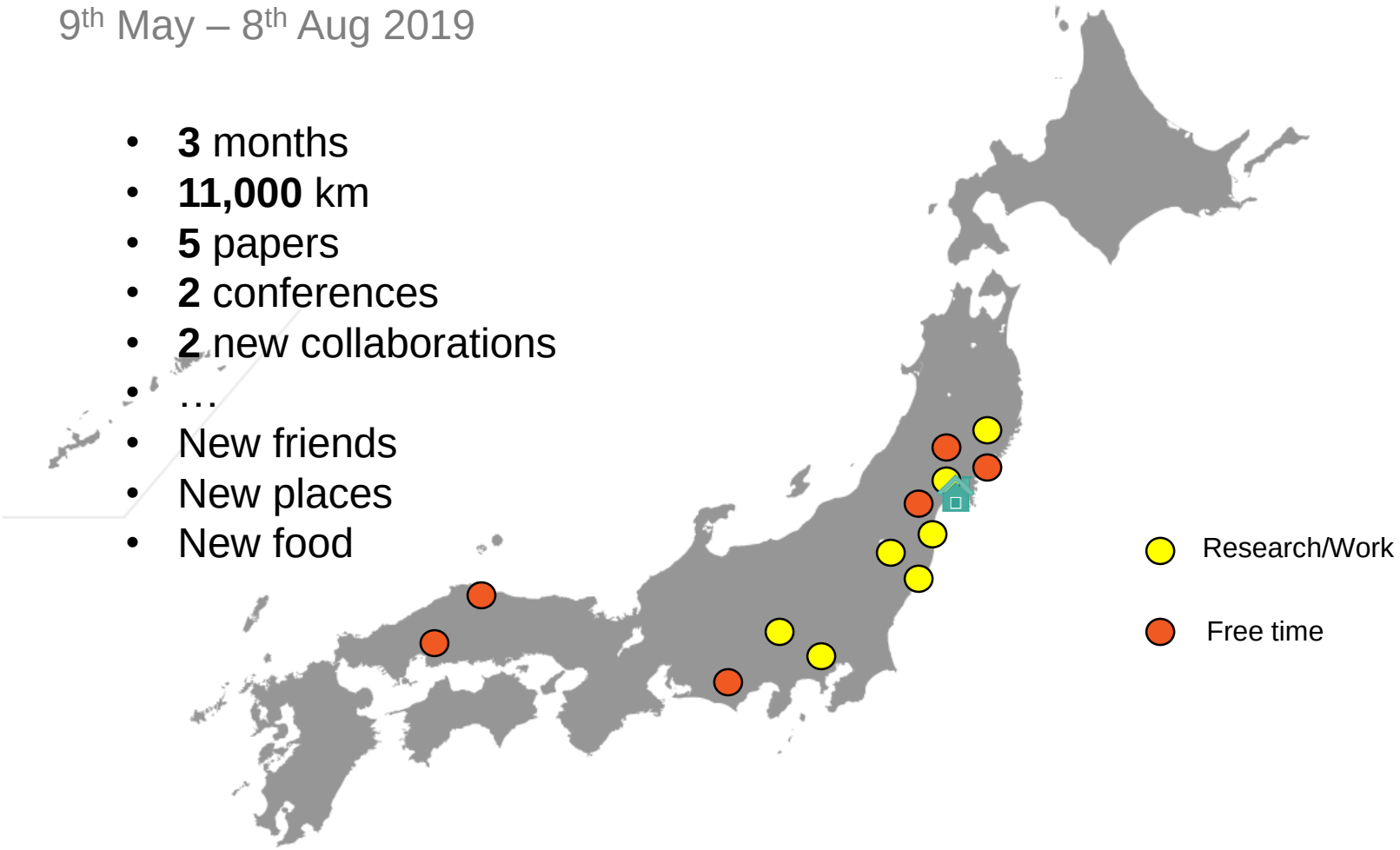
My JSPS experience



My JSPS experience

9th May – 8th Aug 2019

- **3** months
- **11,000** km
- **5** papers
- **2** conferences
- **2** new collaborations
- …
- New friends
- New places
- New food



Research outputs

Papers

Fibre reinforced self-healing cementitious composites
R. Maddalena, S. Koshi, D. Gardner, T. Nishiwaki (in preparation). 2019

Self-healing concrete: Advances in Europe (in Japanese)
R. Maddalena, T. Nishiwaki. Japanese Concrete Institute Journal. 2019

東北大学 TOHOKU UNIVERSITY

Carbon footprint of self-healing concrete in Japan and UK
R. Maddalena, S. Koshi, T. Nishiwaki (in preparation). 2020

Fibre reinforced concrete with self-healing properties (Conference)
R. Maddalena, S. Koshi, T. Nishiwaki. RM4L2020 Int. Conference, Cambridge, UK.

Further Papers

MW FBR technology for diesel-polluted soil remediation
R. Maddalena, K. Seki, G. Mancuso, PP. Falciglia. (in preparation). 2019

東洋大学 TOYO UNIVERSITY

自主創造 日本大学 NIHON UNIVERSITY

Characterisation of high-volume fly-ash concrete
R. Maddalena, S. Pareek. (in preparation), 2020.

Further collaboration

Royal Society and JSPS Research grant: Automated 3D printed Self-Healing Concrete (APSCO)
R. Maddalena and Tomoya Nishiwaki. (submitted)

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Japan Society for the Promotion of Science
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