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Smart Structures: Research Challenges and Business Opportunities

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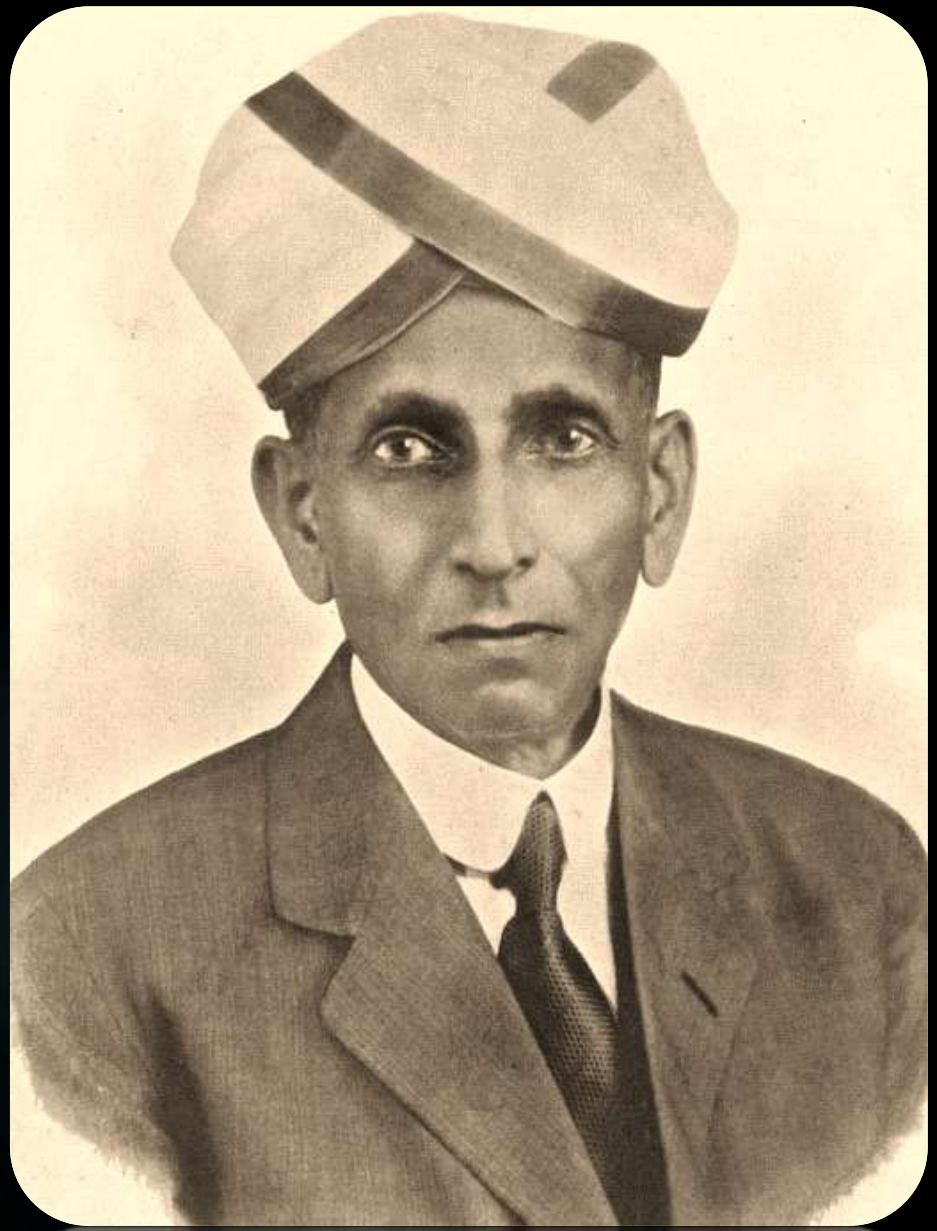
Think & Ink Education and Research Foundation



Dedicated to

Bharata Ratna

Sir M. Visvesvaraya

Structural Failures

Helical Pier Failure

Structural Element Failure

Shear Failure

Staircase Failure

Wall-structure Failure

Hangeul Bridge, Seoul collapsed during construction

Kotwice Trade Hall, Poland

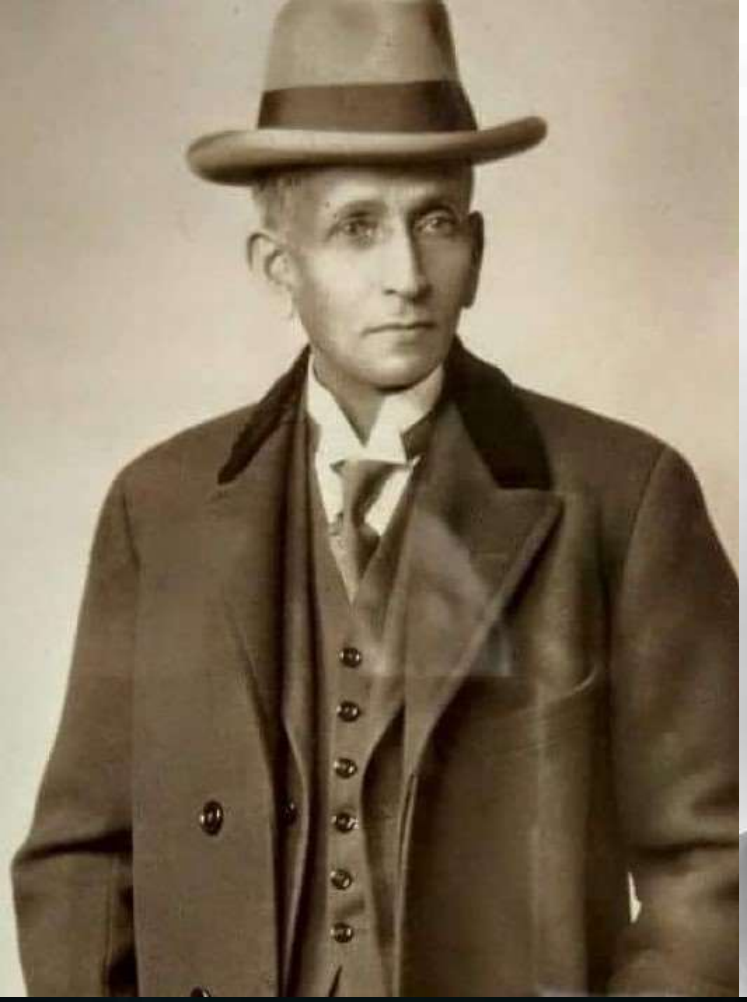
Sampoons Department Store, South Korea

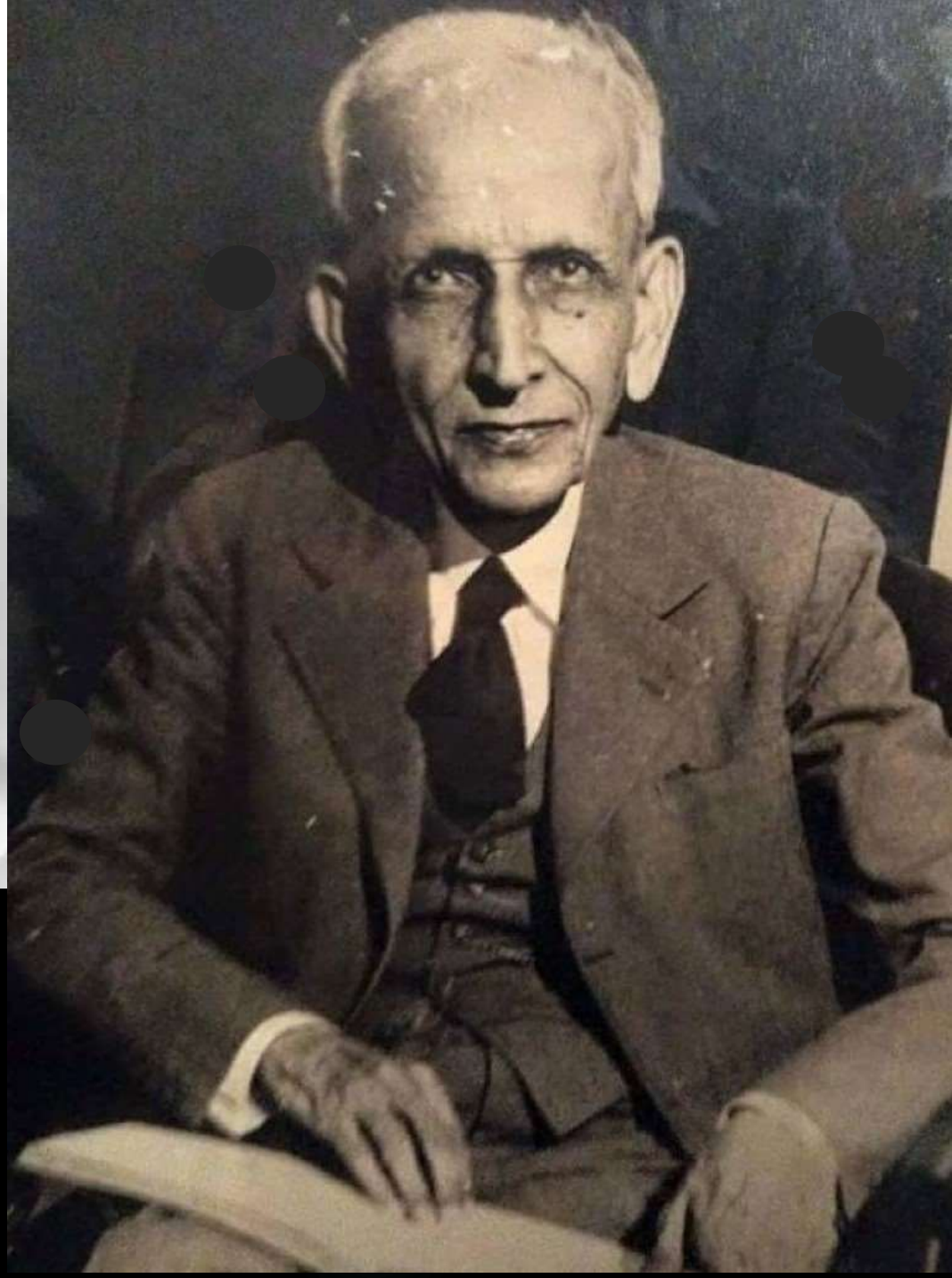
Kaleswarm, TN, India

Sakuma Dam, Korea

KRS Dam, Karnataka

KRS Dam, Karnataka

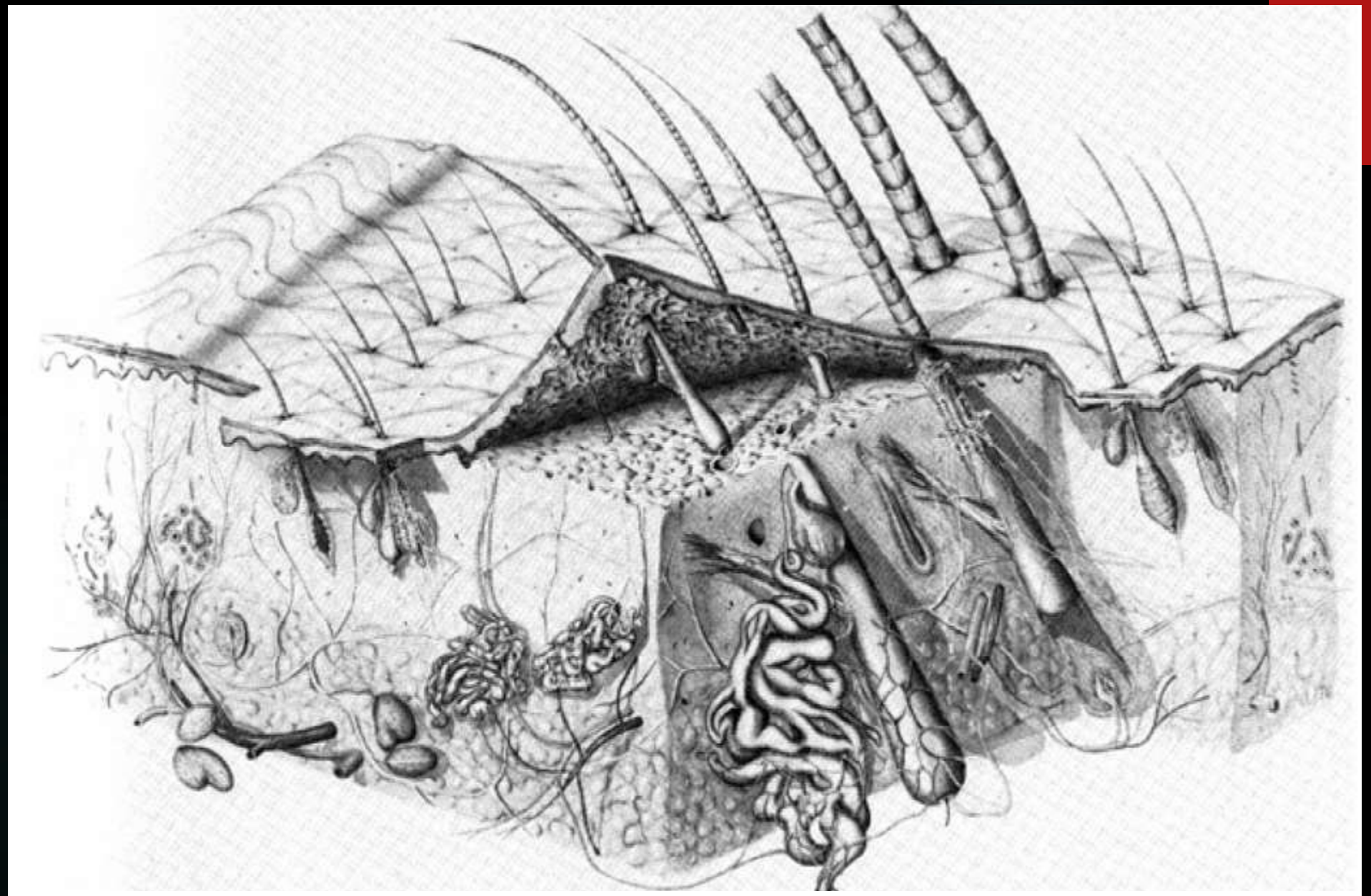




Pioneer of

smart Structural Engineering

KRS Dam, Karnataka

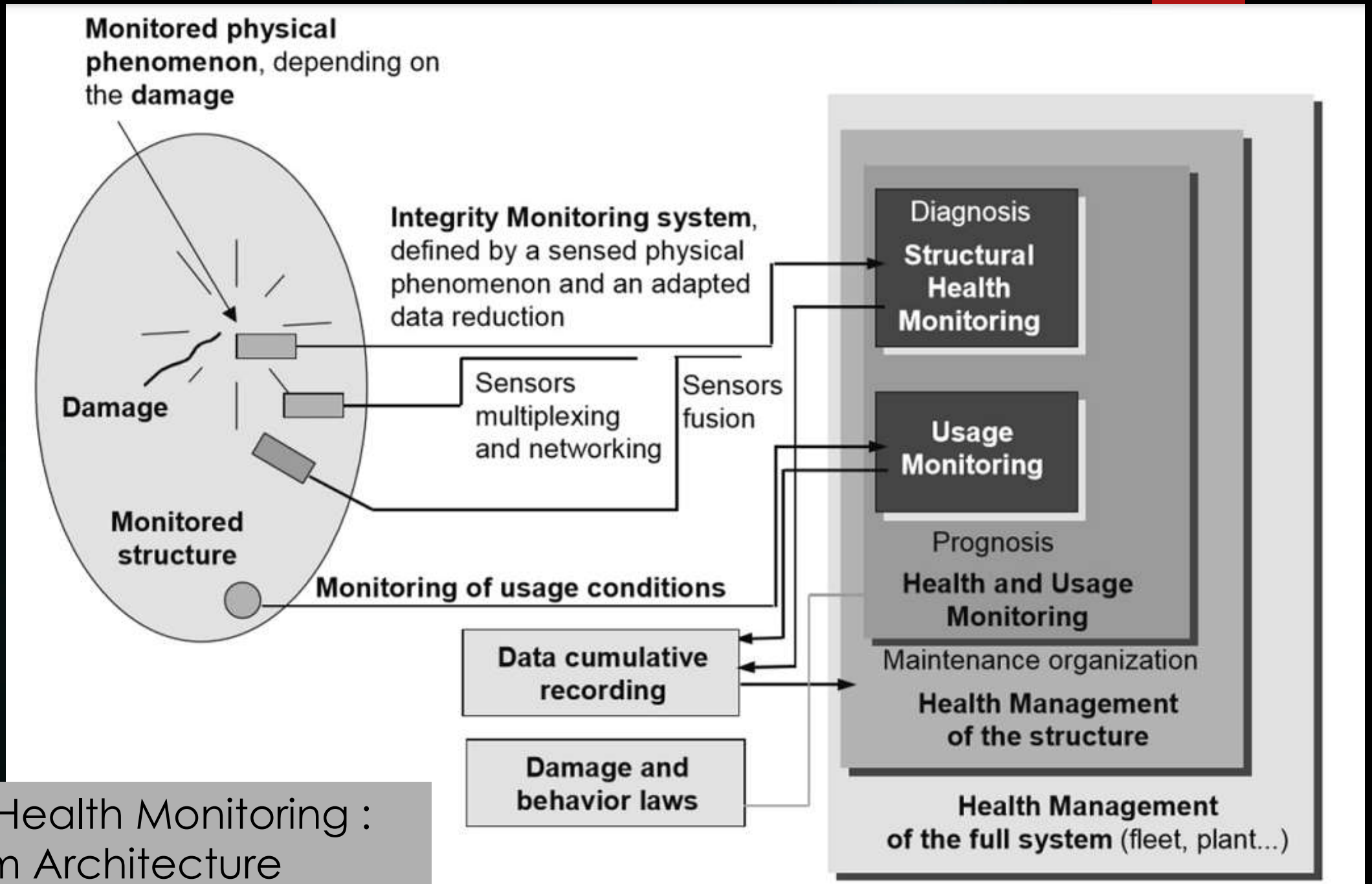


Bio Inspiration: Human Skin

- Structural Health Monitoring (SHM) aims to develop automated systems for the continuous monitoring, inspection, and damage detection of structures with artificial intelligence with minimum labor involvement.

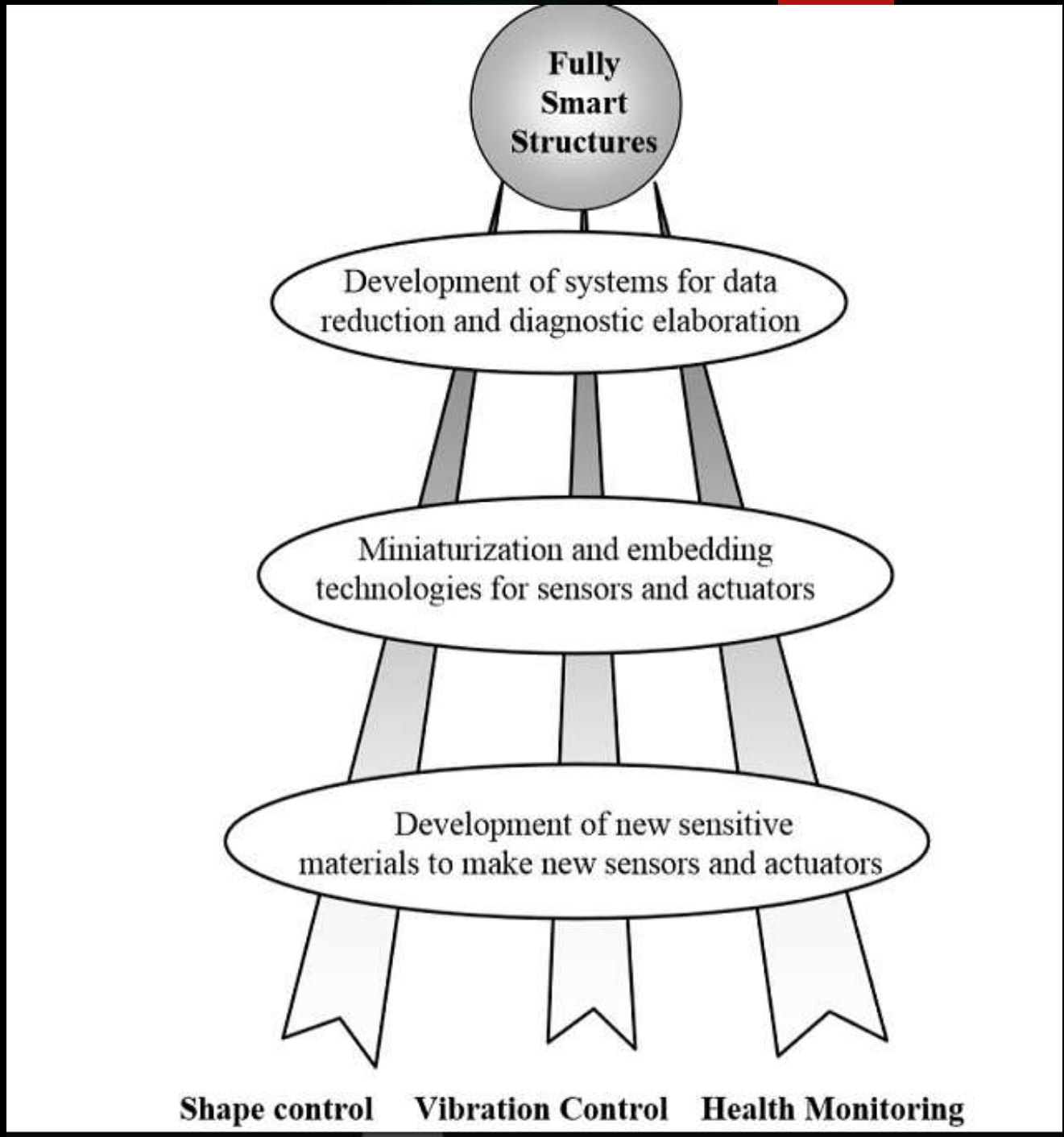
- The first step to set up a SHM system is to incorporate a level of structural sensing capability that is reliable and possesses long term stability.

- Smart sensing technologies including the applications of fibre optic sensors, piezoelectric sensors, magnetostrictive sensors, RFID, GPS and self-diagnosing fibre reinforced composites, possess very important capabilities of monitoring various physical, chemical, environmental and structural parameters related to the structural health and therefore, durable service life of structures.

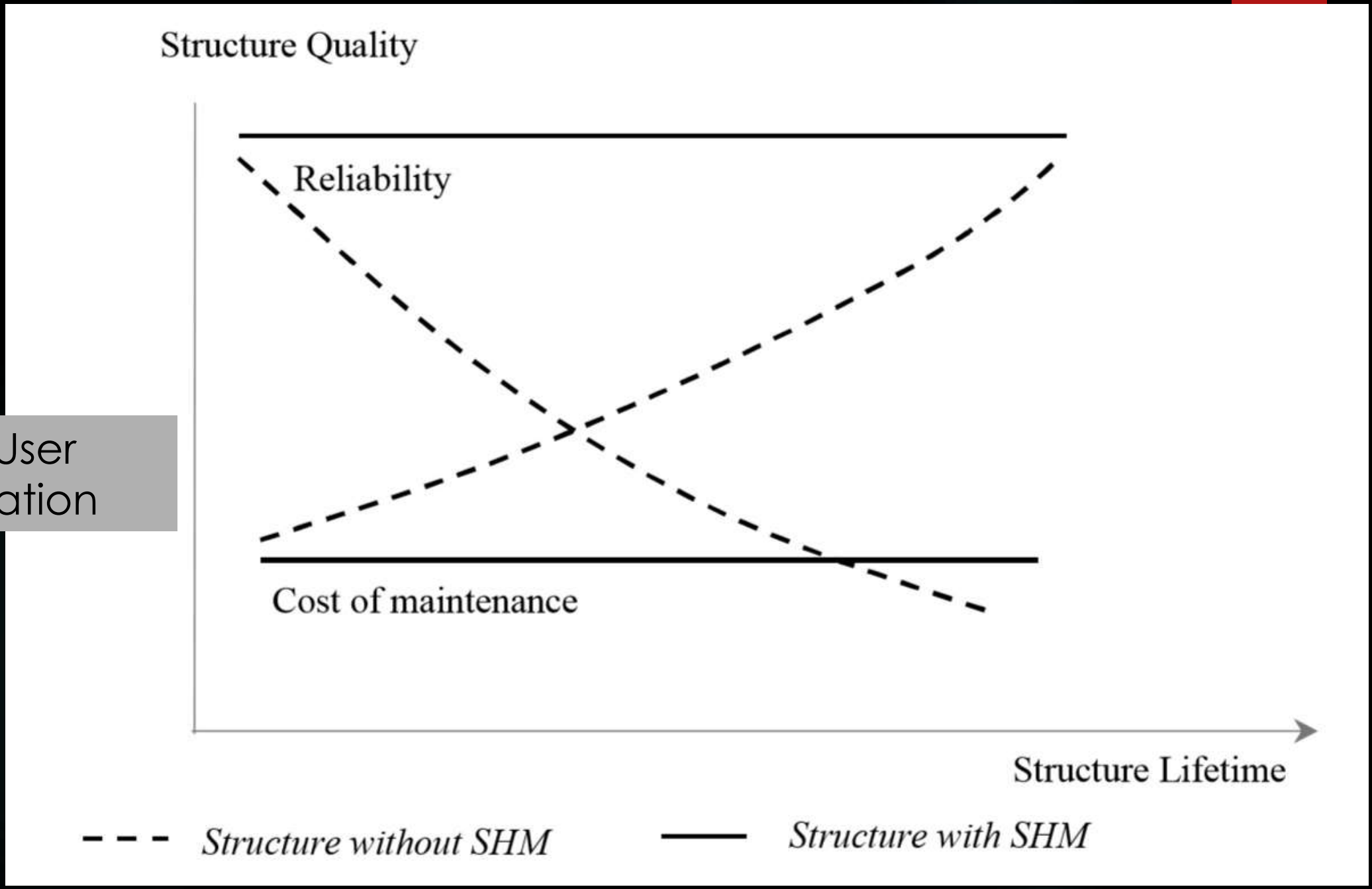


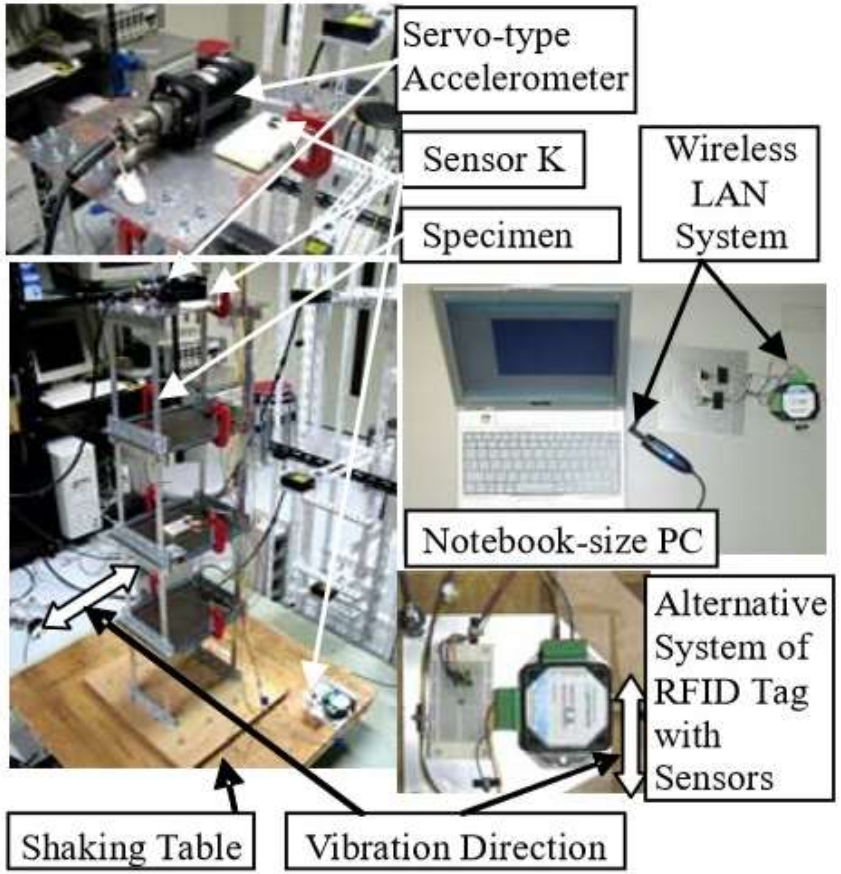
Structural Health Monitoring : System Architecture

Structural Health Monitoring : Integrated System Architecture

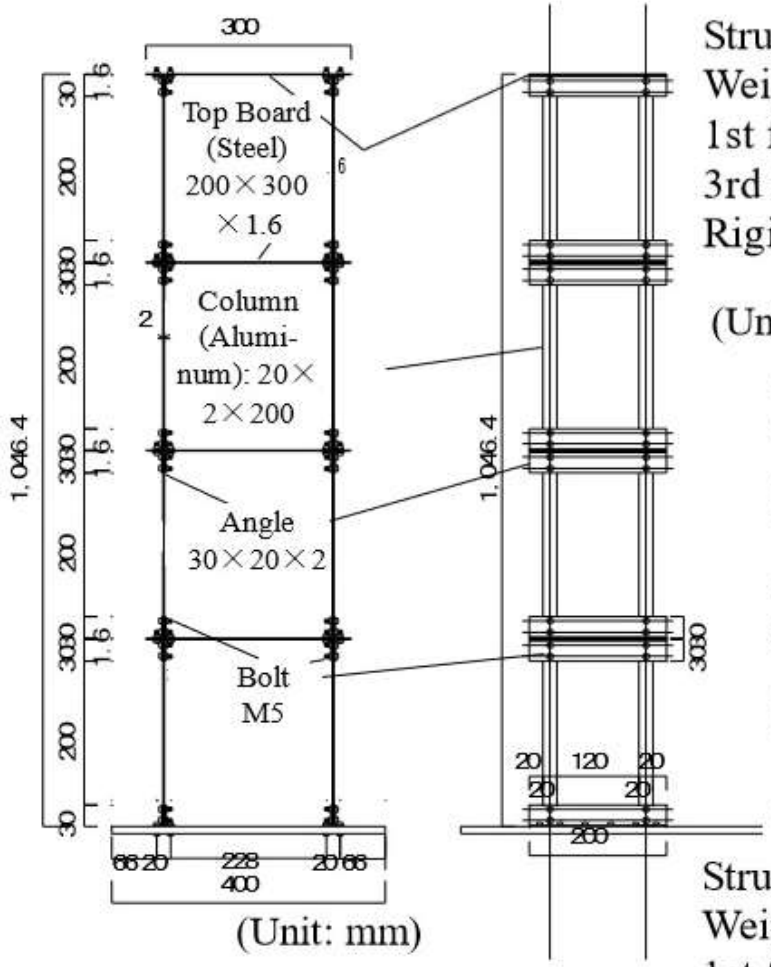


End User Motivation

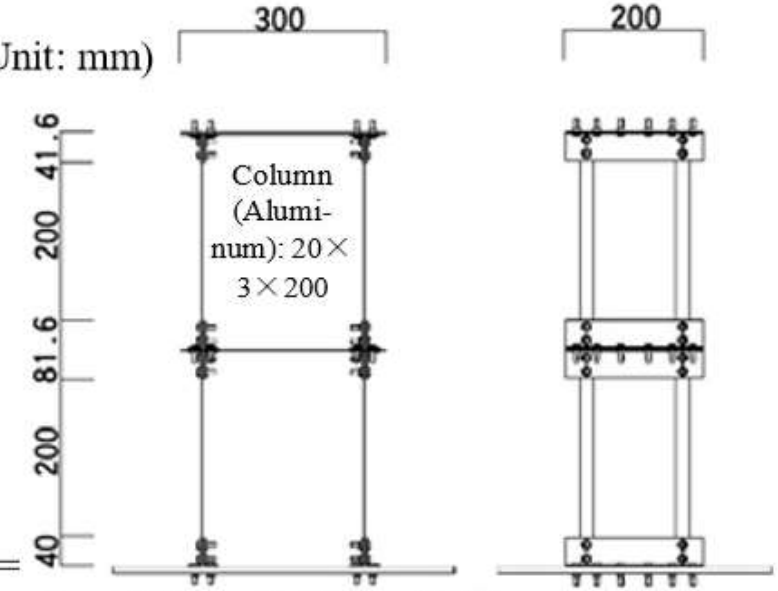




Shaking table test system



Structural Characteristics (4 Story-specimen, Weights with sensors)
1st floor: 1.938 kgf, 2nd floor: 1.969 kgf,
3rd floor: 1.938 kgf, 4th floor: 1.713 kgf
Rigidities of each floor: 3.940 kgf/cm



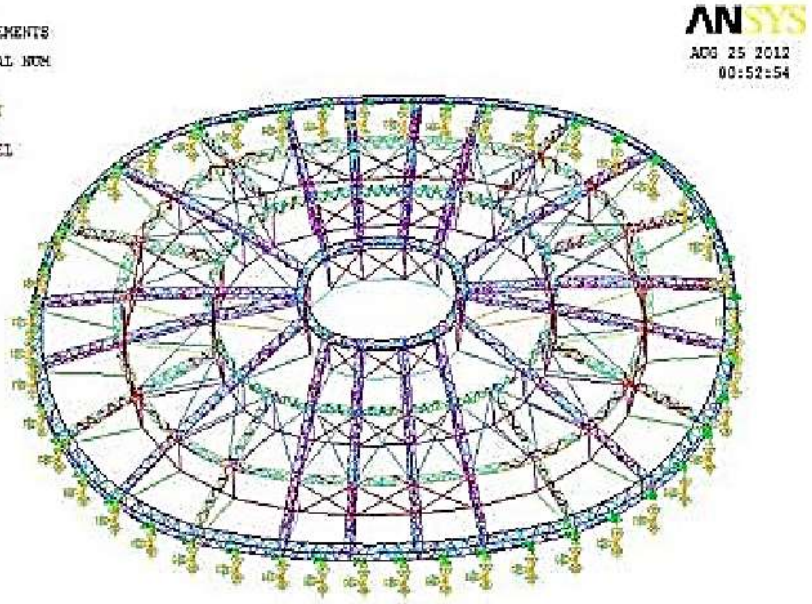
Structural Characteristics (2 Story-specimen, Weights with sensors)
1st floor: 7.069 kgf, 2nd floor: 6.705 kgf,
Rigidities of each floor: 16.53 kgf/cm

4-story and 2-story specimens

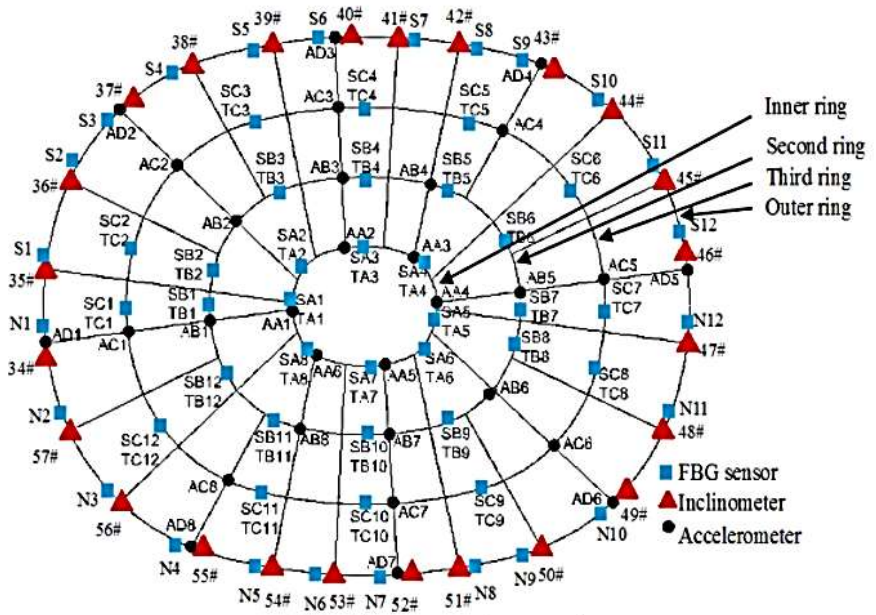
Test Bed with Integrated Health Management System

Smart Buildings & Structures : An example

Dalian Sports Center, China



(a) Dalian Gymnasium FE model



(b) Sensors location

Structural Health Monitoring Systems (SHM) – A China Experience

No	Project Name	Location / Date	Type	Span(m)	Sensors (Amount)	SHM Experience
1	Baling River Bridge	Guangzhou 2009	Susp	1088 (1584)	UW(4);HT(1);FBGT(30);TAcc(2); WIN(2); CFS(64); FBGS(44); TiltM(8); GPS(9); Acc(9);DispS(20);DVC(7)	Member temperature and expansion joint displacement varies with sun angle;
2	Binzhou Yellow River Bridge	Shangdong 2001- 2003	CableS	300 (1698)	GPS(3);AnemS (2); Acc(39);FBGS and FBGT (96).	Wind speed and angle at tower and bridge deck differs not much, Cable forces identified
3	Caiyuanba Yangtze River Bridge	Chongqing 2003- 2007	Tied-arch	420 (800)	StrainS(112); DispS(46); Acc(40); TempS(64); CFS(68)	Tie bar cable force does not exceed the limit.
4	Chongqing Yuao Light Rail Bridge	Chongqing 1999- 2001	RF	160 (352)	Acc(12); TempS (44);StrainS (52);DeflM(11)	Sampling only at certain extreme states to avoid huge data
5	Dongfeng Street Overpass	Jilin 2008	BG	29 (408)	StrainS(48);TempS (14); Thermometer(1);Hygrometer(1);	About 60% of total strain is caused by concrete creep and shrinkage
6	Dafosi Yangtze Bridge	Chongqing 1997- 2002	CableS	450 (1168)	StrainS(40);DT(14);DeflM (42); DispS (4); Acc(20);CFS(97)	Deflection shows cyclical fluctuations similar to the temperature change.
7	Donghai Bridge	Shanghai 2002- 2005	CableS	420 (32.4km)	GPS(3);ExtM(4);CFS(8);StrainS(48); FatM(24);TempS(46);AnemS (3); WaterPG(76);Acc(29);COR(36)	Four layer evaluation system to reduce redundant data
8	Dalian North Bridge	Liaoning 1984- 1986	Susp	132 (230)	GPS(6);Acc	Frequency measured by GPS agrees with Accelerometers
9	Erqi Yangtze Bridge	Hubei 2008- 2011	CableS	616 (1732)	AnemS(5);HT(2);TAcc (3);ASM(8); DT(84); StrainS(173); DeflM(24);	Six evaluation sub-system was designed for different purposes

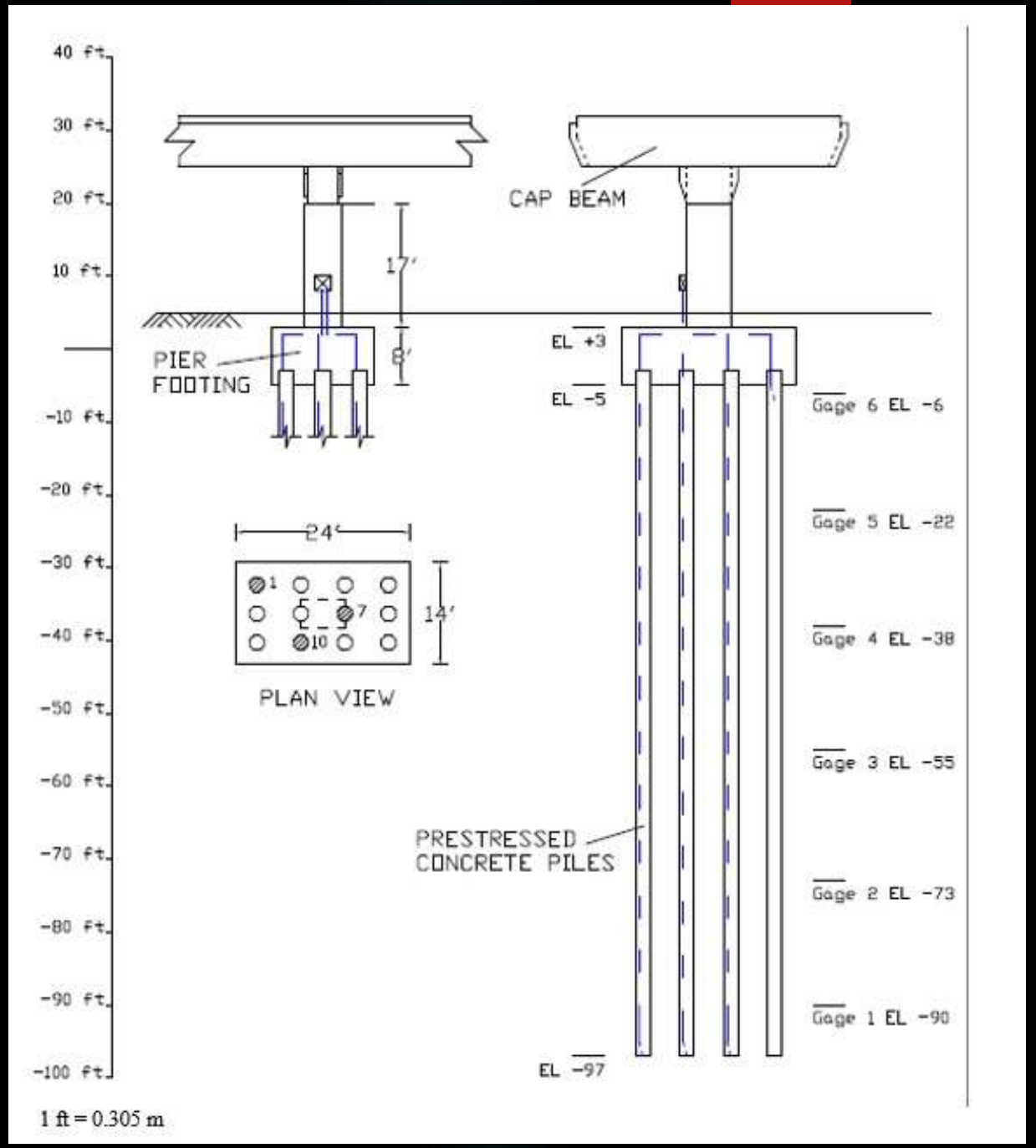
Integrated Structural Health Management Systems: USA

Smart Foundation Engineering, USA


Smart Windows,
Germany

Short Term Monitoring, Bangalore India

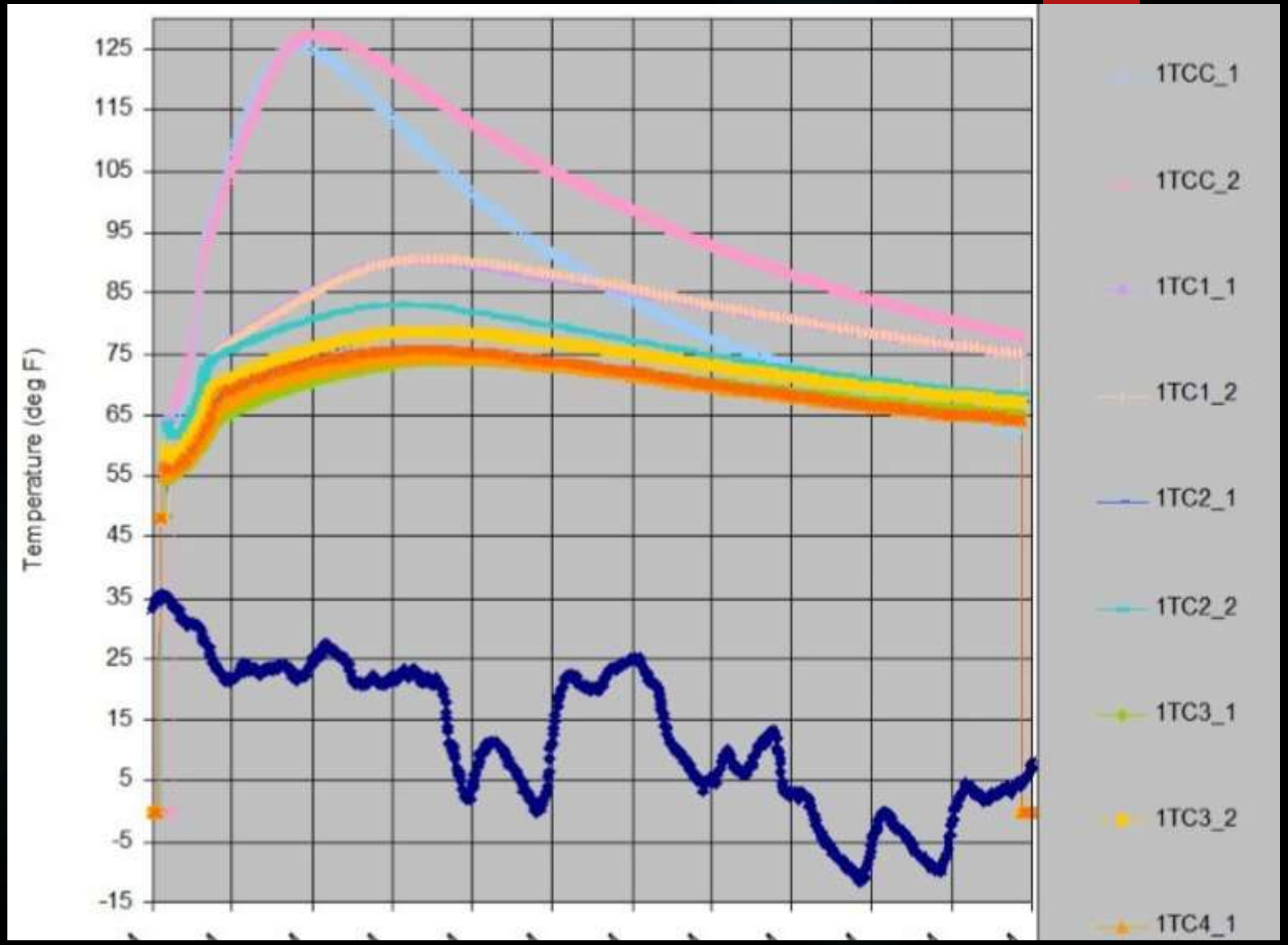
Pier A 31 – 221 with Instrumentation Bus with Sensor Integration



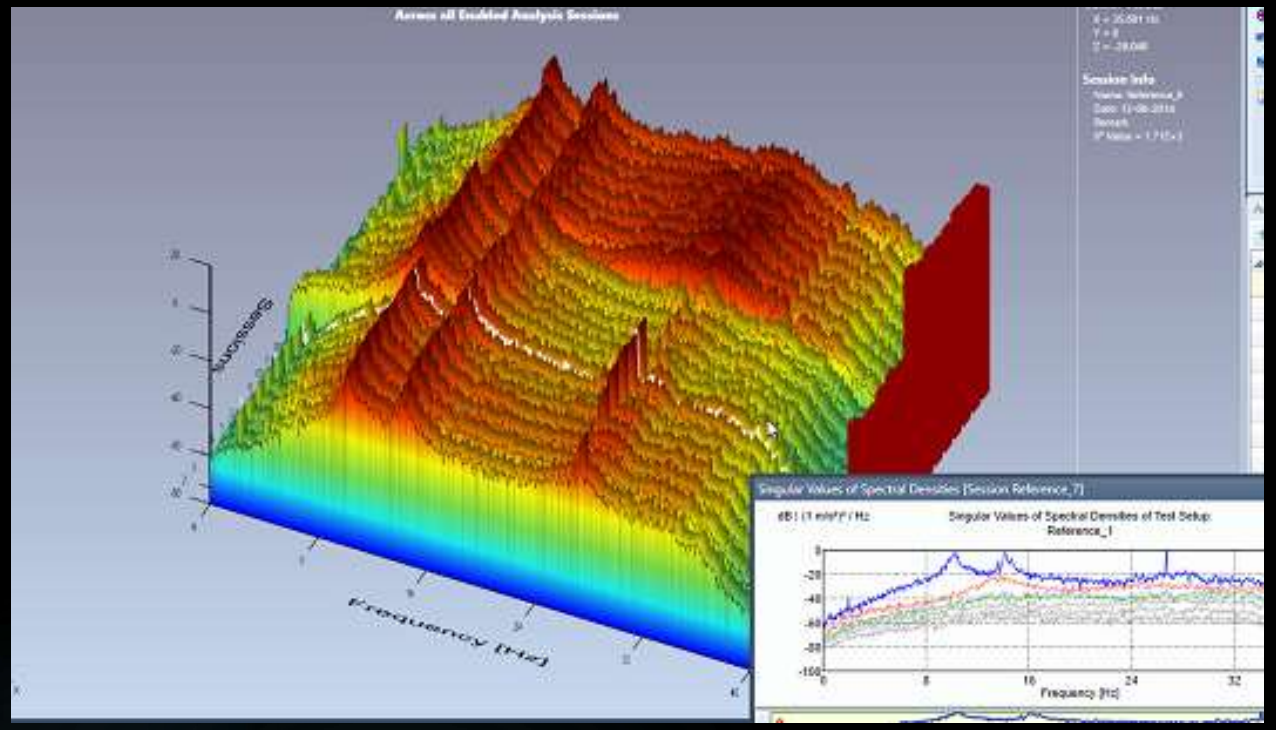
Preliminary Research Results

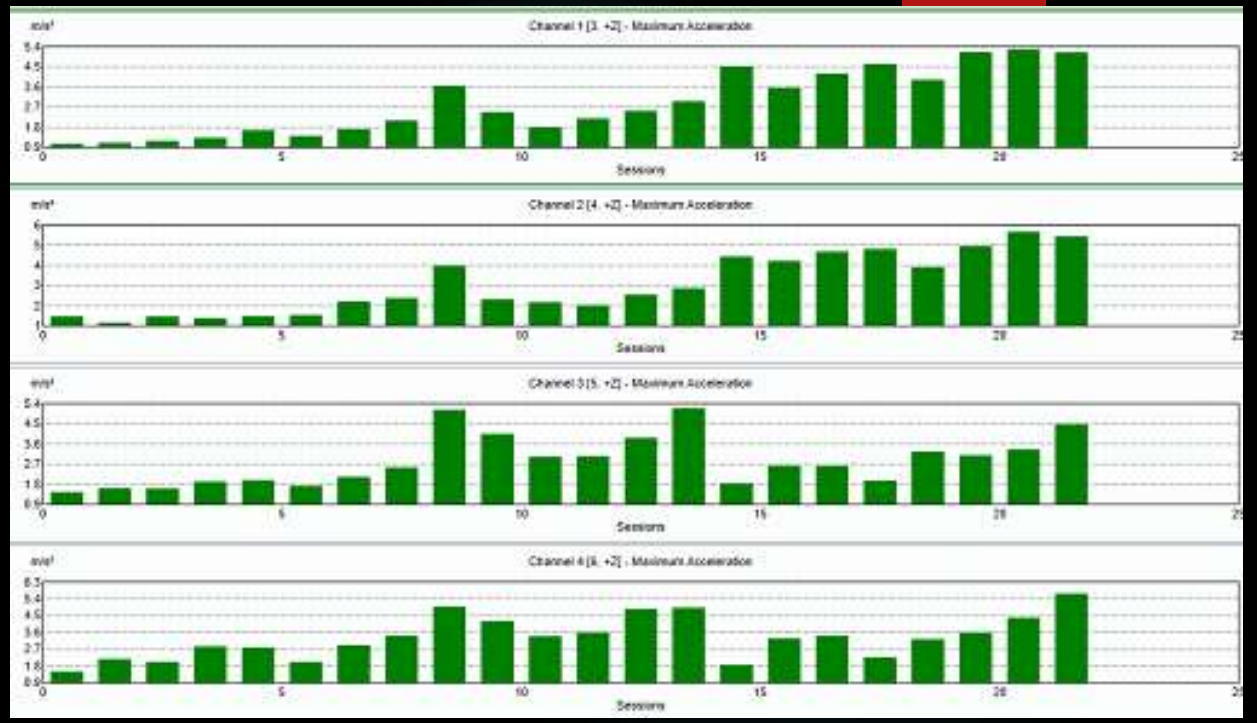
Voided Shaft with Thermo couples (TC) in centre casting for thermal modelling and monitoring

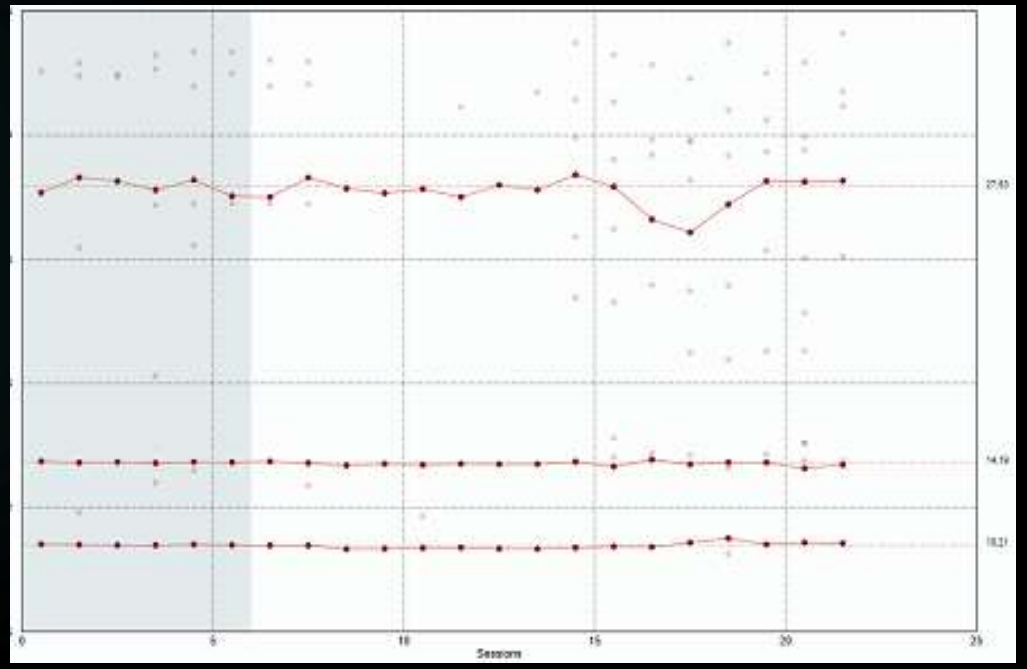
Thermal Data Processing and Visualization

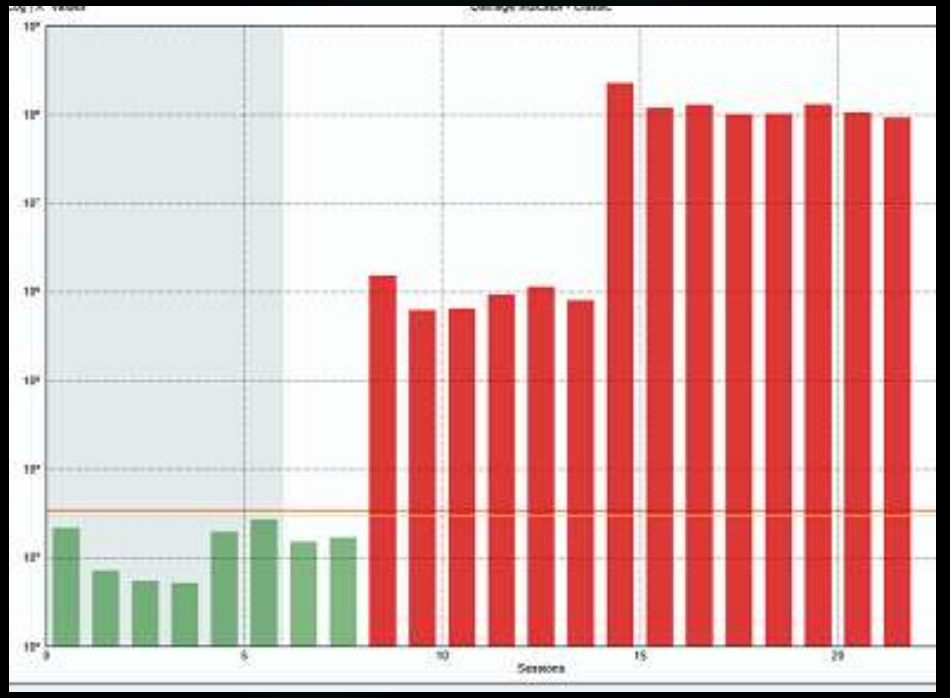


SHM System with Data Visualization and Analytics

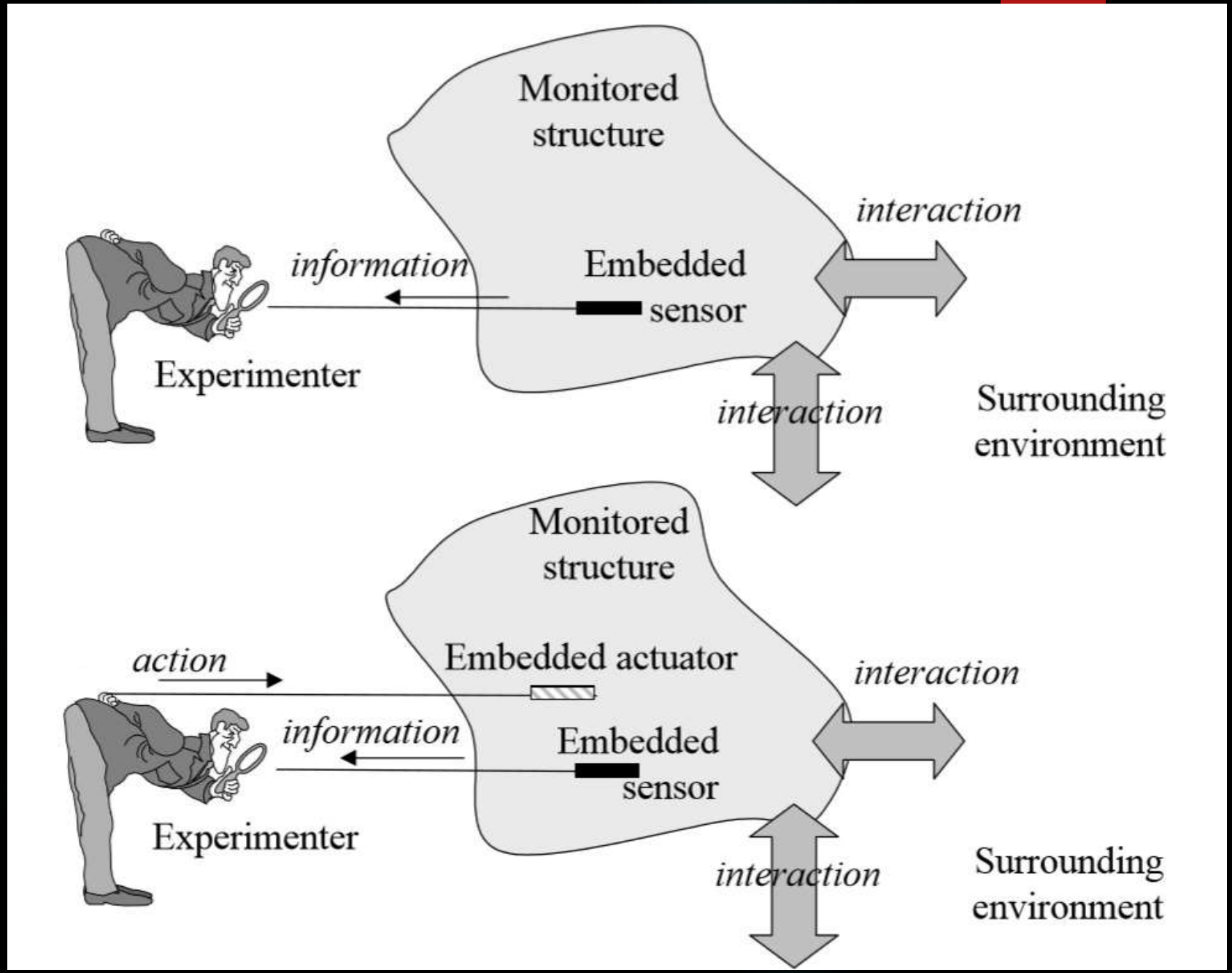


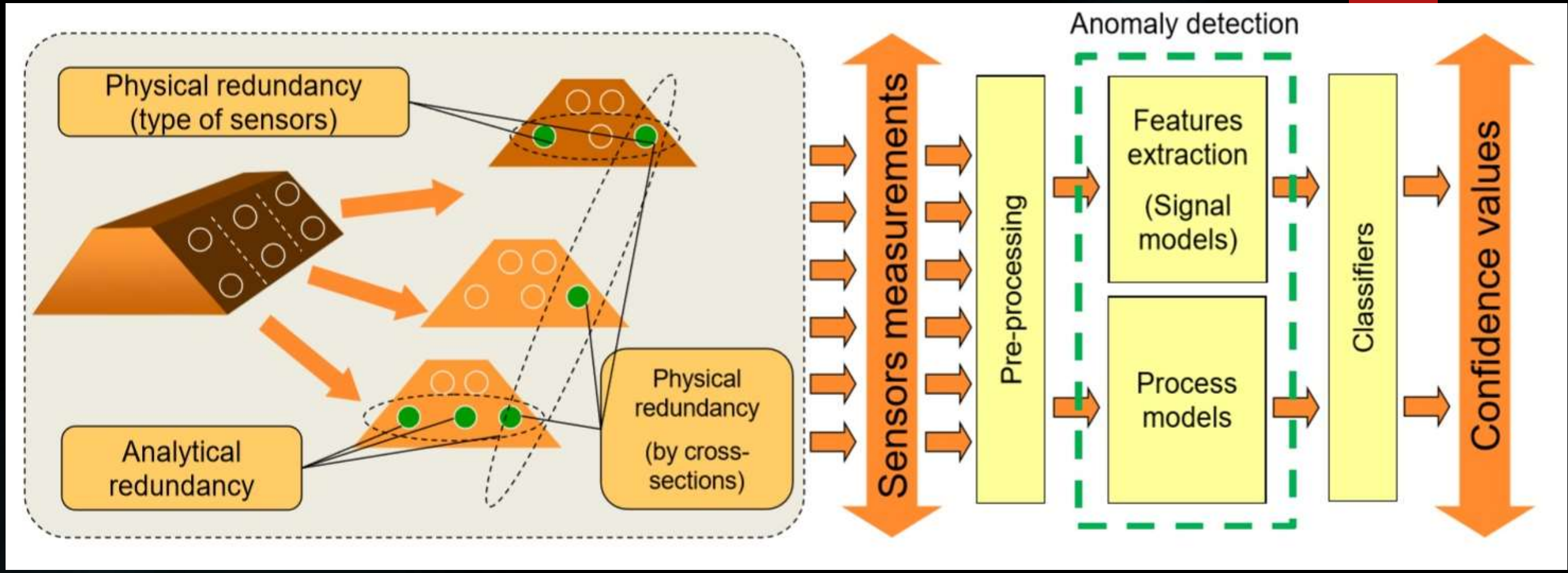




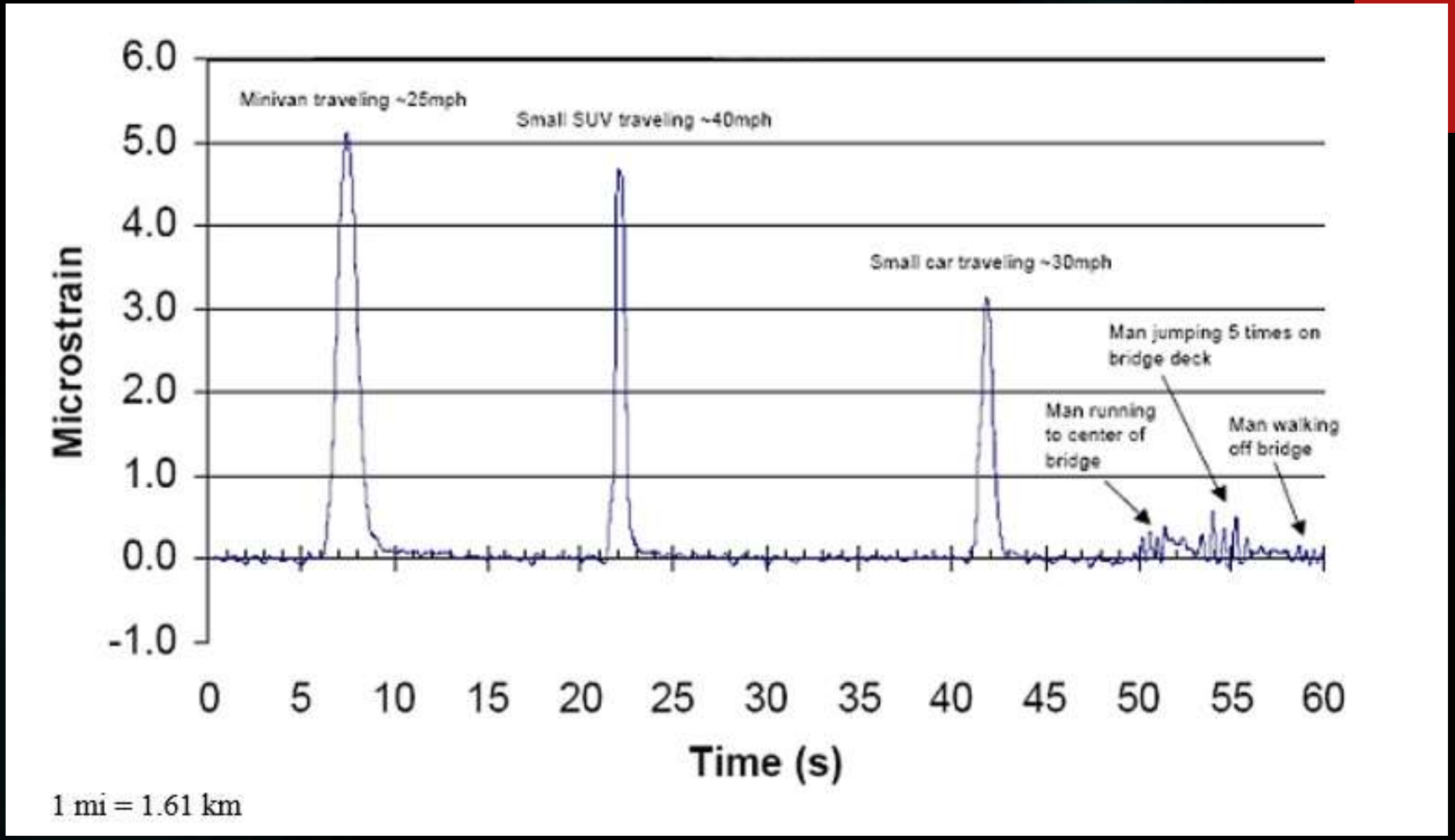


Passive and Active Monitoring

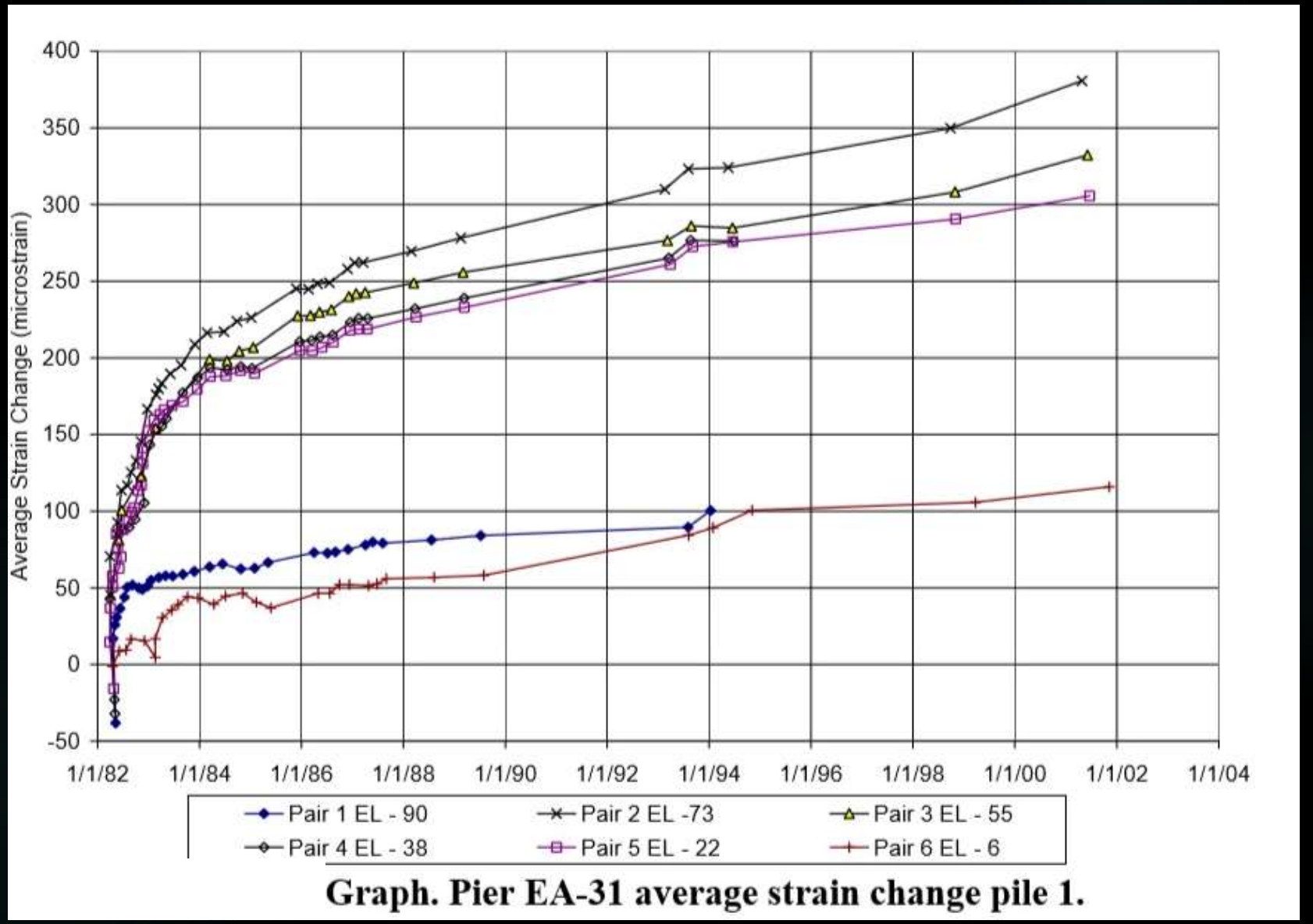




Anomaly Detection : Time and Frequency Domain – DSP Techniques

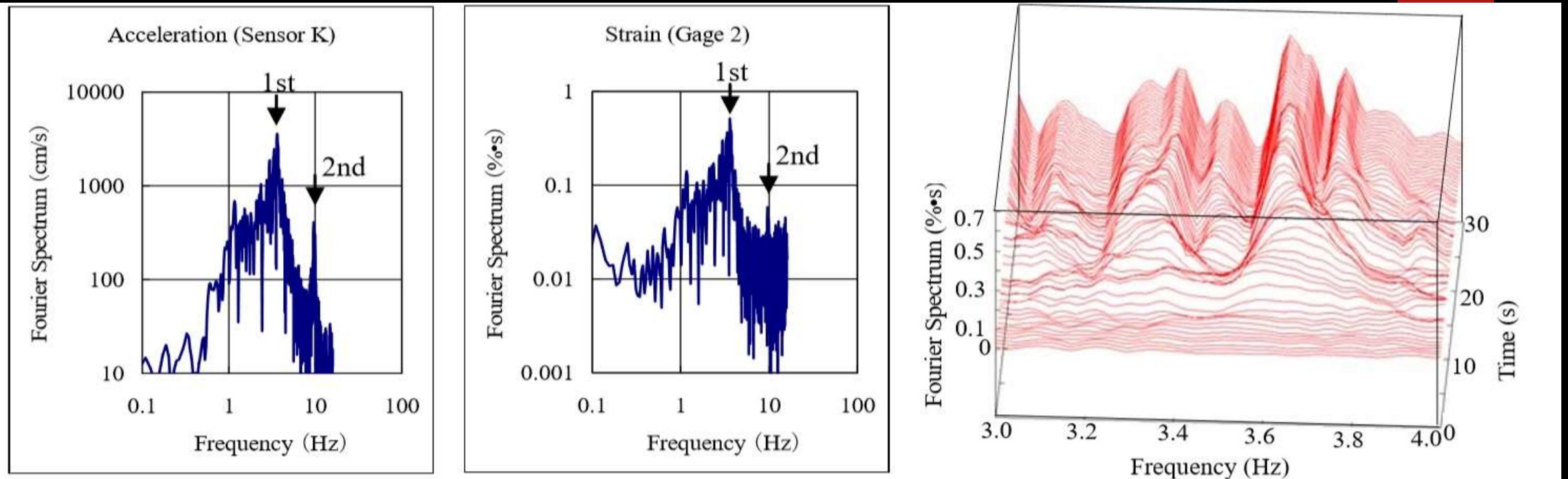


Strain on Bridge Structure with different loads – DSP Techniques



Graph. Pier EA-31 average strain change pile 1.

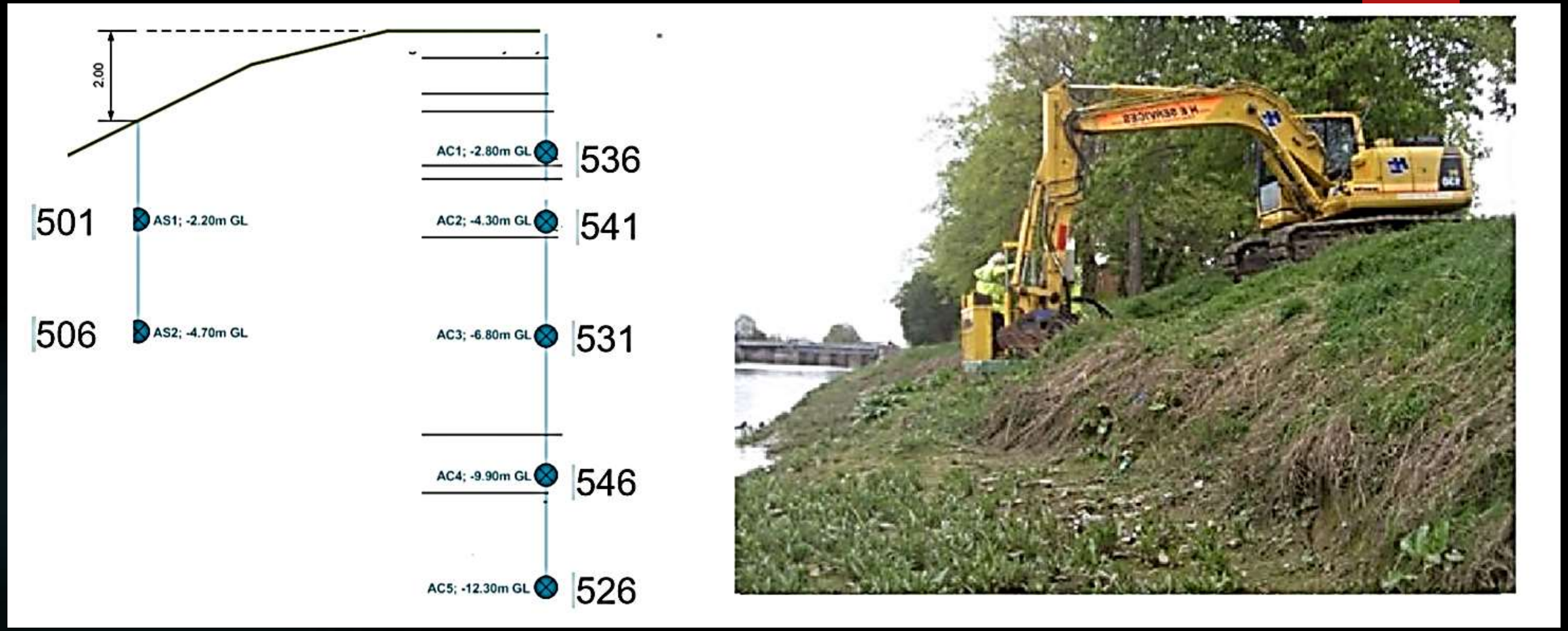
Strain gauge data from a sensor



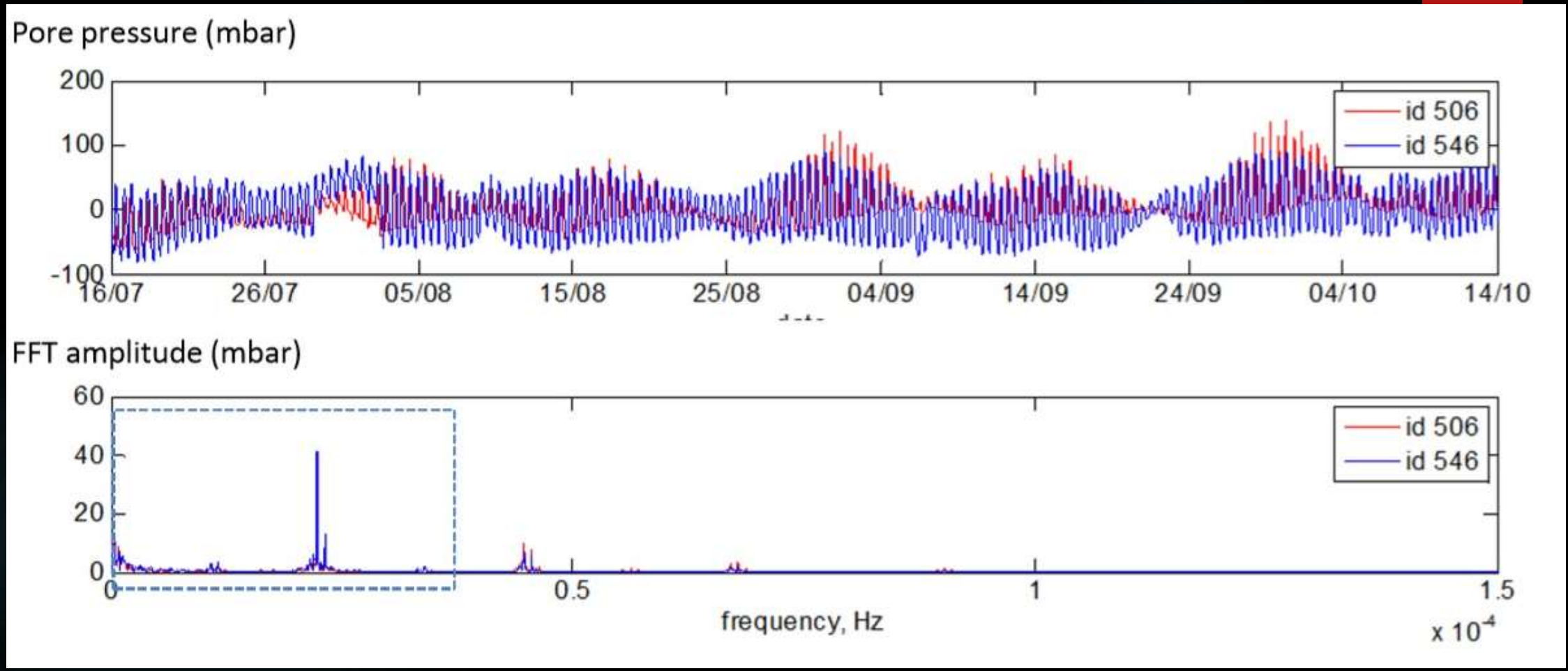
(a) Acceleration (b) Strain by Gage-2 (c) Progressive Fourier spectrum by Gage-2

Results of FFT analyses in case of 2-story specimen (Case 4)

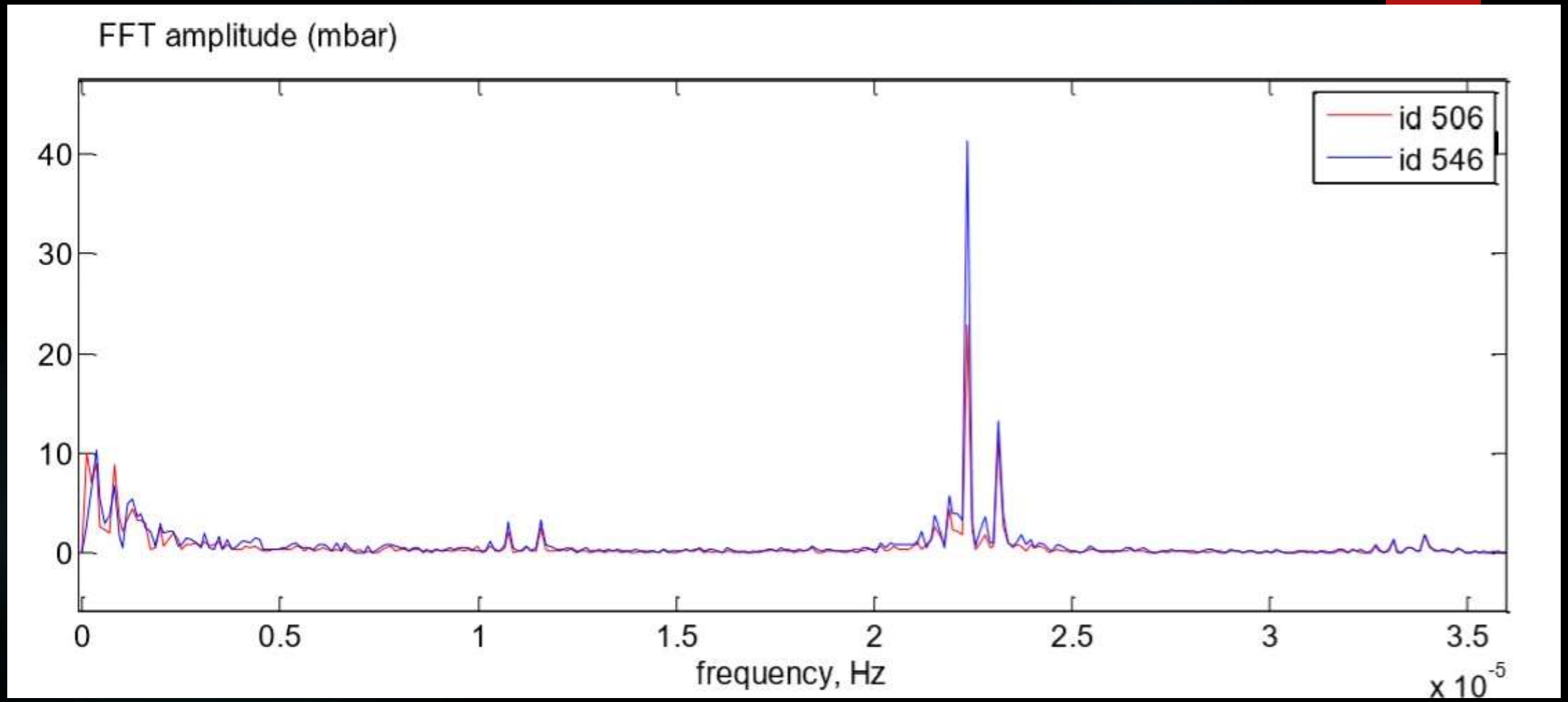
DSP and FFT Techniques



Pore Pressure Sensors



Pore Pressure Sensors with Spectrum Analysis



Pore Pressure Sensors with Spectrum Analysis (Zoom in)

Looking for :

- Research Collaborations – Industry & Academia
- Technological Partners
- Innovation and Technology Transfer
- Business Partners/Investors
- Contract Research Opportunities
- Advanced Mathematical Modelling
- Sensor Design and DSP
- Sensor Placement Standards
- SMH Reference Architecture
- Field Trials and Documentation
- Software Development

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BMS College of Engineering, Bengaluru

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