OMAINTEC CONFERENCE EXHIBITION 2017
15th INTERNATIONAL OPERATIONS & MAINTENANCE CONFERENCE IN THE ARAB COUNTRIES
23-25 OCTOBER
HILTON HABTOOR GRAND HOTEL // BEIRUT // LEBANON
أكاديمية الشارقة للبحوث
Sharjah Research Academy

EDUCATING FOR SMART MAINTENANCE: CHALLENGES OF ACADEMIA

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History Of Education

History of Maintenance

Importance and Need for Maintenance

Smart Maintenance

Development Concrete Education Requirement

University Maintenance Programs

Continuous Education In Maintenance

Observations

HISTORY OF EDUCATION

EDUCATION OF SURVIVAL WAS ONE OF THE OLDEST PROFESSIONALS IN HISTORY

ASIA

NALANDA UNIVERSITY, INDIA, 600BC

The university was said to entertain over 10,5000 students at a time. The passing rate was just 3 out of 10. IT SAW STUDENTS FROM BABYLON, GREECE, SYRIA, AND CHINA. Nalanda was the world's first university to have residential quarters for both students and teachers.

The glorious history was only for 800 year. It was destroyed thrice in history with first two destruction rectified. The third one(1300) was permanent till 2006. It is now rebuilt and rearing to achieve its old days of Glory under the eyes of Amartya sen.

COLLEGE OF ENGINEERING, GUINDY, INDIA, 1749

It was established in 1794 by British colonialists as School of Survey, this institution is the oldest engineering school in India and is currently a constituent college of Anna University, Chennai. The school became the Civil Engineering School in 1858 and was then rechristened as College of Engineering in 1861.

KYOTO UNIVERSITY, *JAPAN, 1869*

The forerunner of the Kyoto University was the Chemistry School founded in Osaka in 1869, which, despite its name, taught physics as well. Kyoto University, or Kyodai is a national university located in Kyoto, Japan. It is the second oldest Japanese university, one of the highest ranked universities in Asia and one of Japan's National Seven Universities.

UNIVERSITY OF TOKYO, *JAPAN, 1877*

The university was chartered by the Meiji government in 1877 under its current name by amalgamating older government schools for medicine and Western learning. It was renamed "the Imperial University," in 1886, and then Tokyo Imperial University in 1897 when the Imperial University system was created.

Arab & Islamic Countries

AL-KARAOUINE IN FES, MOROCCO ,859

- The First oldest institute of Islamic world which is still in operation.
- It only has natural science at the beginning. Other mainstream science was added in 1957.
- This was built as a mosque to begin with and slowly expanded to become the largest in Africa and it has statues as old as university itself

AL-AZHAR UNIVERSITY, EGYPT ,970-972

- The second oldest institute of Islamic world which is still in operation.
- It started as center for studying Arabic literature, Sunni Islamic learning and religious focus.
- Today it teaches Quaranic sciences and traditions along with learnings from Prophet Muhammad on one hand and all modern fields of science on other.

AL NIZAMIYYA, IRAQ , 1065

- The education offered required no fee.
- Nizamiyyah institutes were among the first well organized institutions of higher learning in the Muslim world.
- The quality of education was among the highest in the Islamic world.

AL-MUSTANSIRIYA UNIVERSITY, IRAQ, 1227

The original Mustansiriya Madrasah, was established in 1227 (or 1232/34 A.D. by some accounts) by the Abbasid Caliph Al-Mustansir and was the oldest complete university in the world. Its building, on the left bank of the Tigris River, survived the Mongol invasion of 1258 and has been restored.

AL- ADILIYAH SCHOOL, SYRIA, 1215

Located in Bab Al-Bareed (the Mail gate), right across Al-Zahiriyah School. It was constructed in The Ayoubi Age in 1215 A.D. by King Sayf Eddeen, the sibling of Saladin. It was considered Arabic Language Academy.

ISTANBUL UNIVERSITY, TURKEY, 1453

Istanbul University was established in 1453 by the Ottoman Sultan Mehmed II. However, Richard Honig, a German law historian, who claims that Byzantine and Ottoman traditions could be analyzed together, expressed that the history of Istanbul University can be traced back to 1 March 1321.

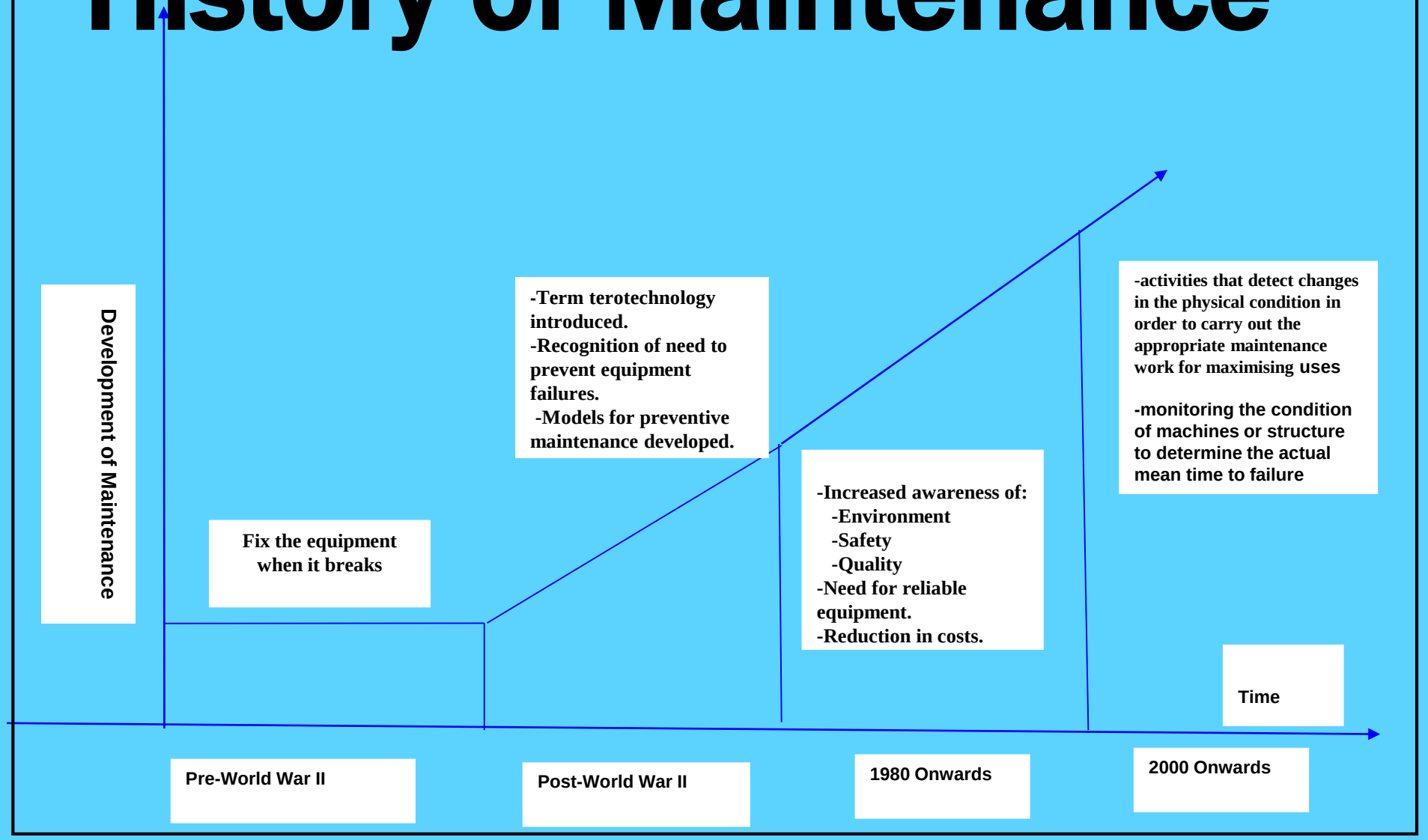
UNIVERSITY OF INDONESIA, INDONESIA, 1851

University of Indonesia is the oldest tertiary-level educational institution in Indonesia. The roots of UI date back to 1851. It is generally considered as the most prestigious public university in Indonesia.

AMERICAN UNIVERSITY OF BEIRUT, LEBANON, 1866

The American University of Beirut (AUB) is a private, secular, and independent university in Beirut, Lebanon. It was established in 1866. Degrees awarded at the American University of Beirut (AUB) are officially registered with the New York Board of Regents.

History of Maintenance



RUN TO FAILURE MAINTENANCE (RTF) ,

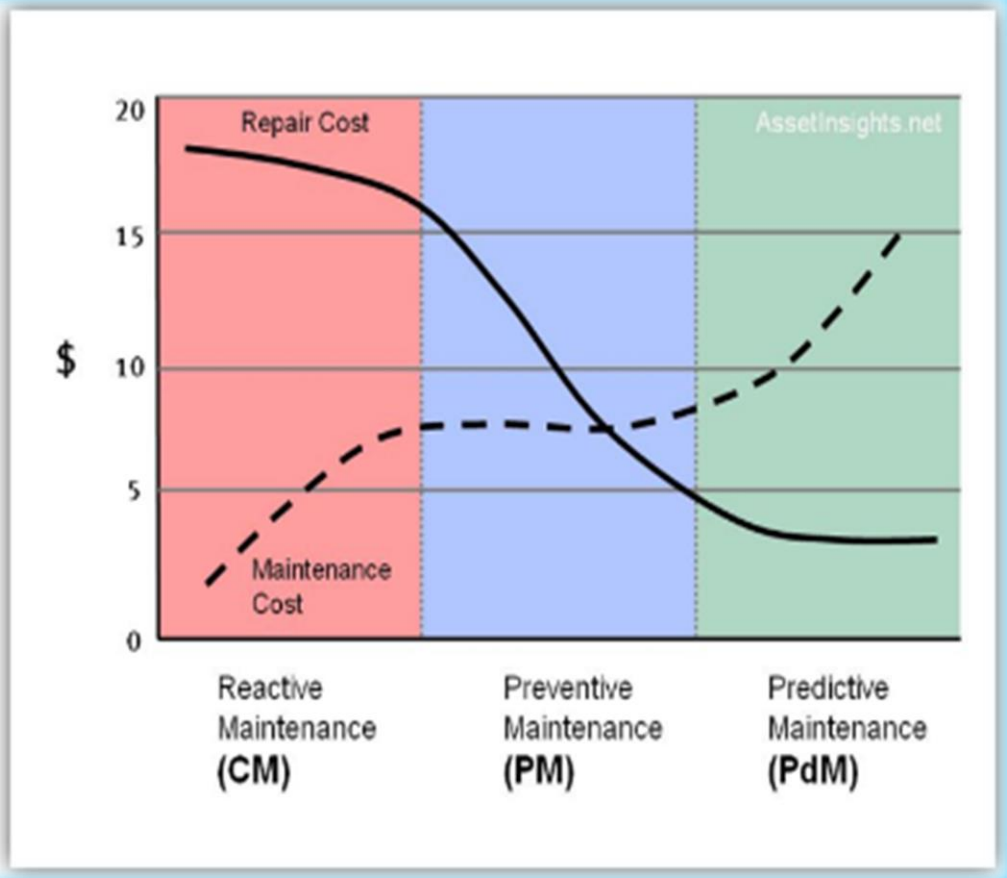
PREDICTIVE MAINTENANCE (PDM

PREVENTIVE MAINTENANCE (PM), CORRECTIVE MAINTENANCE (CM), IMPROVEMENT MAINTENANCE (IM),)

Ref.Shenoy, Bhadury 1998)

Implantations of Smart Maintenance in Concrete

Corrective Maintenance	Repair It After It Breaks	High Cost Overtime
Planned Maintenance	Repair It Before It Breaks	Scheduled Coordinated
Predictive Maintenance	Don't Repair It Eliminate the Root Cause	Life Extension Labour Reduction

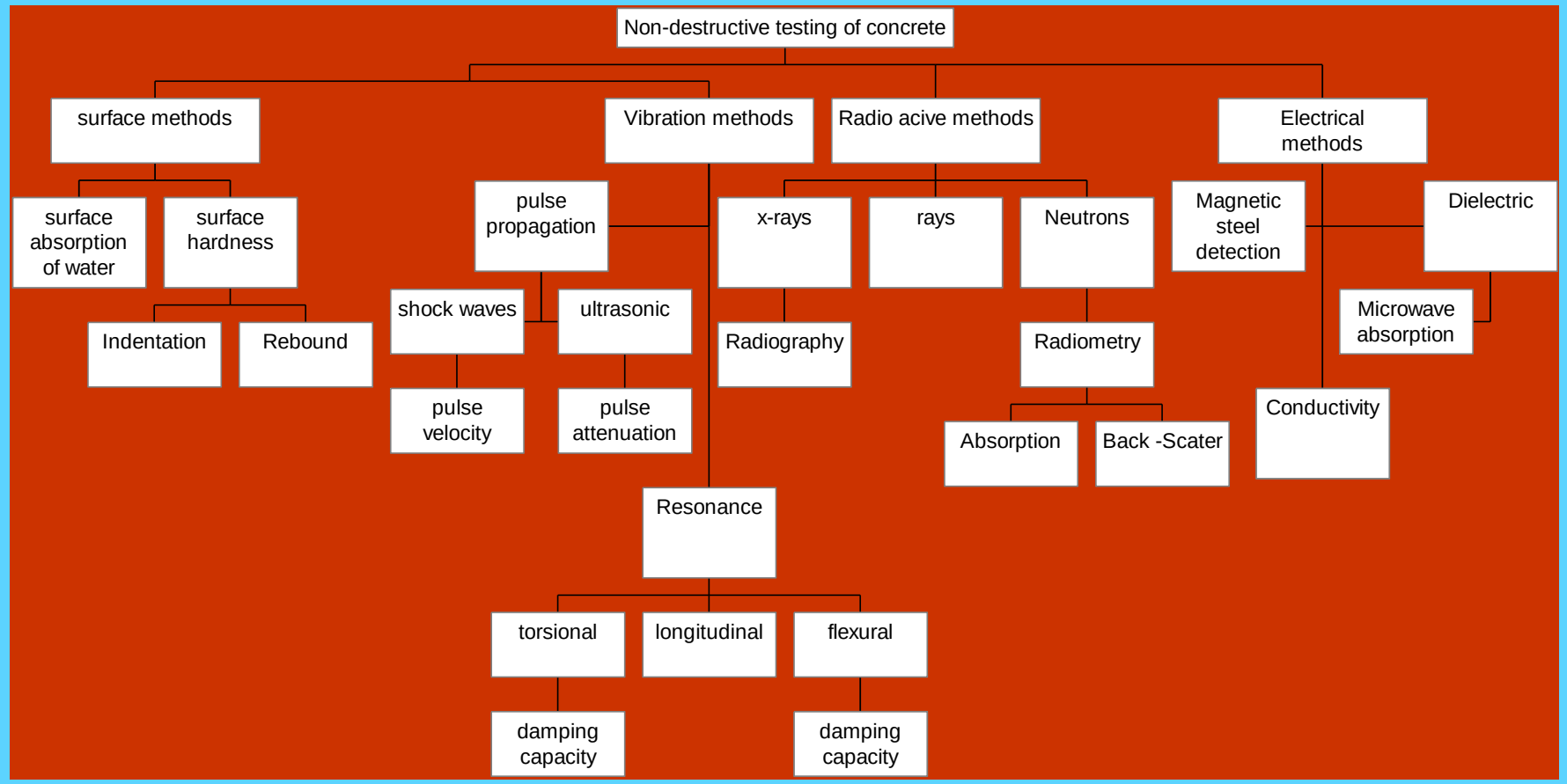


Source : https://www.linkedin.com/pulse/machine-learning-predictive-maintenance-manuel-dias

Importance and Need for Maintenance

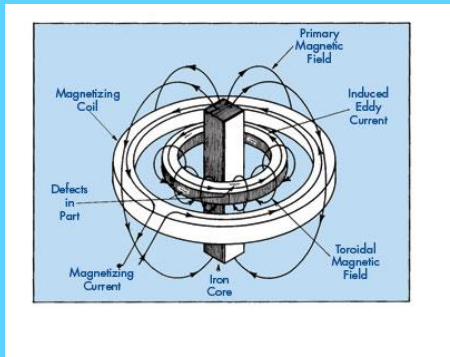
- Although accurate figures are hard to come by, it is estimated that the world spend about US $5.0 Trillion on construction
- In the United States conservative estimates of the current cost to rehabilitate deteriorating concrete structures are in the 130 billion dollar range.
- . Around 50% of the expenditure in the construction industry in Europe is spent on repair, maintenance and remediation.

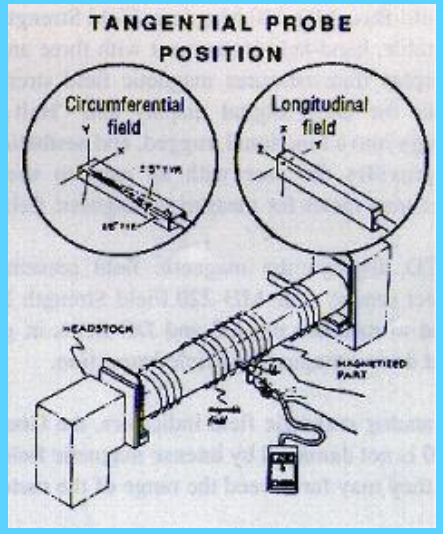
SMART TESTING



Magnetic Particle Inspection (MT)

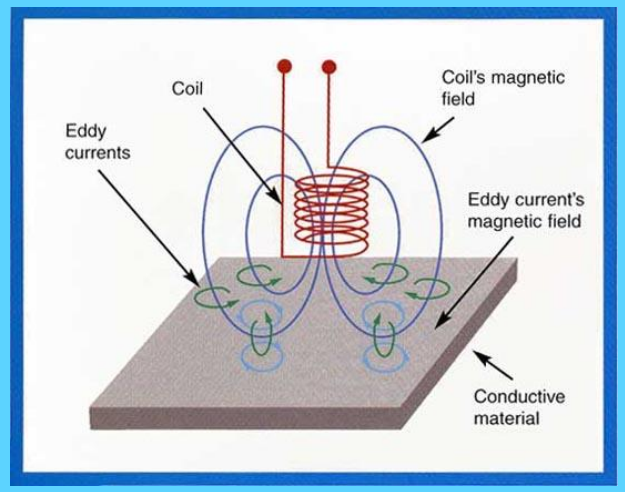
Common NDT method that is capable of detecting surface and subsurface defects in ferrous materials. **The method involves the induction of a magnetic field to or around the test specimen.** If the material has a surface or near surface flaw it will create magnetic flux. These magnetic fluxes will attract small magnetic particles to the flaw area making it detectable. Also known as Magnetic Particle Inspection (MPI)





Eddy Current Testing

Eddy current testing uses electromagnet induction in conductive materials to detect flaws. This method can detect very small flaws in or near the surface of the material. It is limited to conductive material and the surface must be accessible.



Radiographic Testing (RT)

This (NDT) inspection method uses **wavelength electromagnetic radiation to penetrate various materials to detect flaws.** This x-ray detection can be used on lead and steel to detected external and internal flaws but cannot be used on plastics. Radiation Safety is very important when using this testing method due to the possible exposure to strong gamma sources in remote sites.

X-Ray Diffraction

- X-ray diffraction (XRD) is a Qualitative and Quantitative non-destructive analytical technique allows you to look at X-ray scattering from crystalline materials.

- Today about 50,000 inorganic and 25,000 organic single component, crystalline phases, and diffraction patterns have been collected and stored on magnetic or optical media as standards.

Concrete Resistivity

Related to the conductivity of concrete

Corvib RESI Resistivity Meter

Resitivity (kΩ cm)	Corrosion
p ≤ 8	Fairly Certain
8 < p < 12	Possible
p ≥ 12	Improbable

NDT James RM-8000 Resistivity Meter

Resitivity (kΩ cm)	Possible Corrosion Rate
< 5	Very high
5 to 10	High
10 to 20	Moderate/Low
>20	Insignificant

Ground Penetration Radar (GPR):

It can be used to locate rebar, voids, delamination of concrete deck, and thickness of layers (With or without asphalt layer).

- Uses pulsed electromagnetic radiation to scan concrete.
- The antennas can be placed on a moving vehicles !
- Standardized by ASTM D6087, 2008.

- **Disadvantages:** Cannot directly detect delaminated areas. (needs moisture in it)
- Cannot provide mechanical properties of concrete ,nor corrosion of reinforced steel.

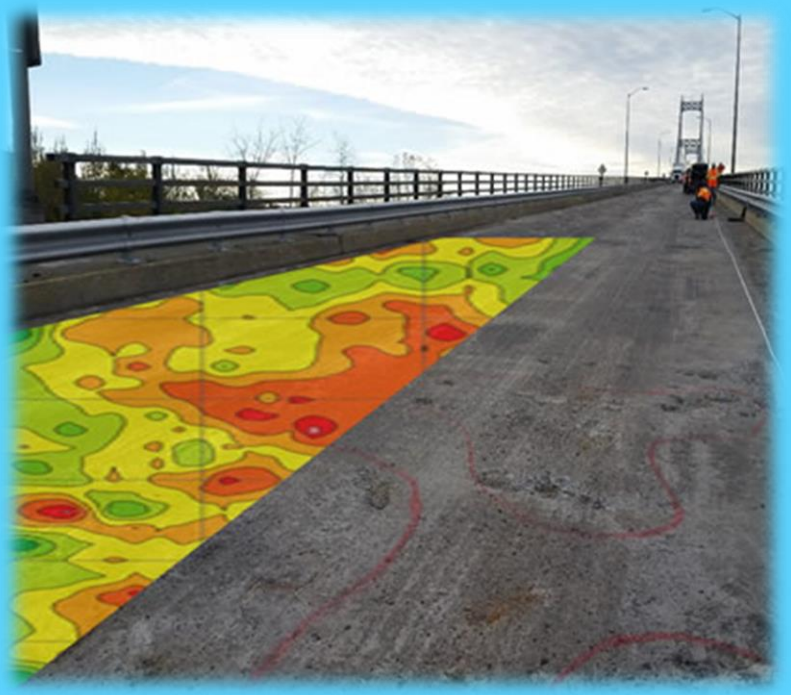


Figure 12: Ultrasonic Pulse Velocity inaction , Source: http://www.fprimec.com/4-methods-of-condition-survey-for-bridge-decks/e/

http://www.fprimec.com/4-methods-of-condition-survey-for-bridge-decks/

SMART MONITORING

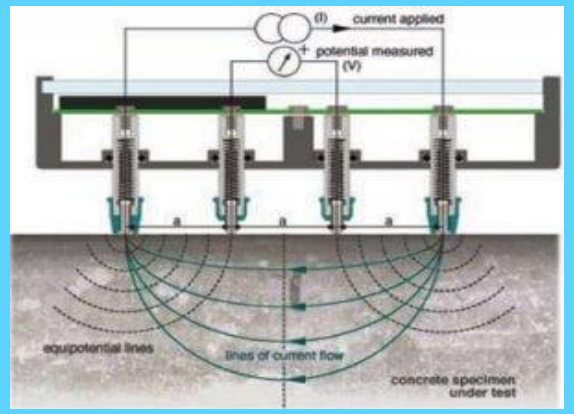
The engineering community is becoming increasingly interested in the monitoring of the structural behavior and in new tools allowing the assessment of structural integrity and performances.

Reinforced Concrete structures are especially interesting because of their prevalence in the ground transportation infrastructure and because of the increasing attention accorded to the behavior of aging structures.

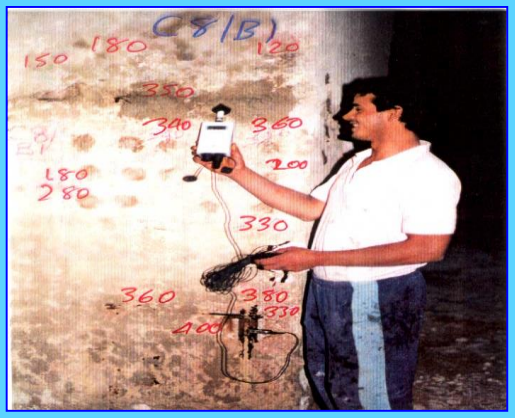
Corrosion Monitoring of Reinforced Concrete Structures

Chain Drag Delamination Survey

Electrical Resistivity Measurement



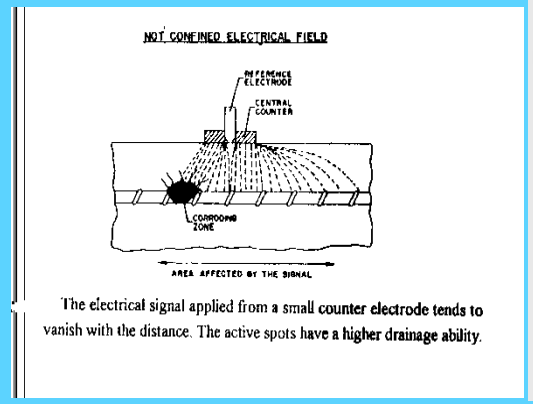
Half-Cell Corrosion Potential Mapping



Corrosion Rate Measurement

Ground Penetrating Radar – GPR

Linear Polarization Resistance Measurement



The electrical signal applied from a small counter electrode tends to vanish with the distance. The active spots have a higher drainage ability.

Table 7.2 Typical corrosion rates for steel in concrete

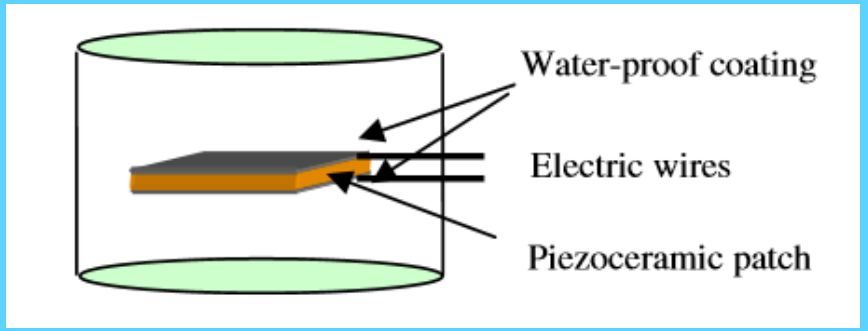
Rate of corrosion	Corrosion current density, i_{corr} ($\mu A/cm^2$)	Corrosion penetration, p (μm/year)
High	10→100	100→1000
Medium	1→10	10→100
Low	0.1→1	1→10
Passive	<0.1	<1

Guided-Wave Ultrasonic Testing Current status

- A company in UK has a commercially available called "Permanently Installed Monitoring System" (PIMS). PIMS have already been installed on around 100 buried pipes.
- The system can be pre-installed on pipe and then installed subsea and cabled back to platform. Retrofit installation by diver or ROV is also possible.
- So far offshore installations have mainly been above splash zone on risers in the North Sea and offshore in South America

Implantations of Sensors in Monitoring

The impedance-based health monitoring approach:
qualitative damage detection method. The operating principle is based on the electromechanical coupling property of piezoelectric materials

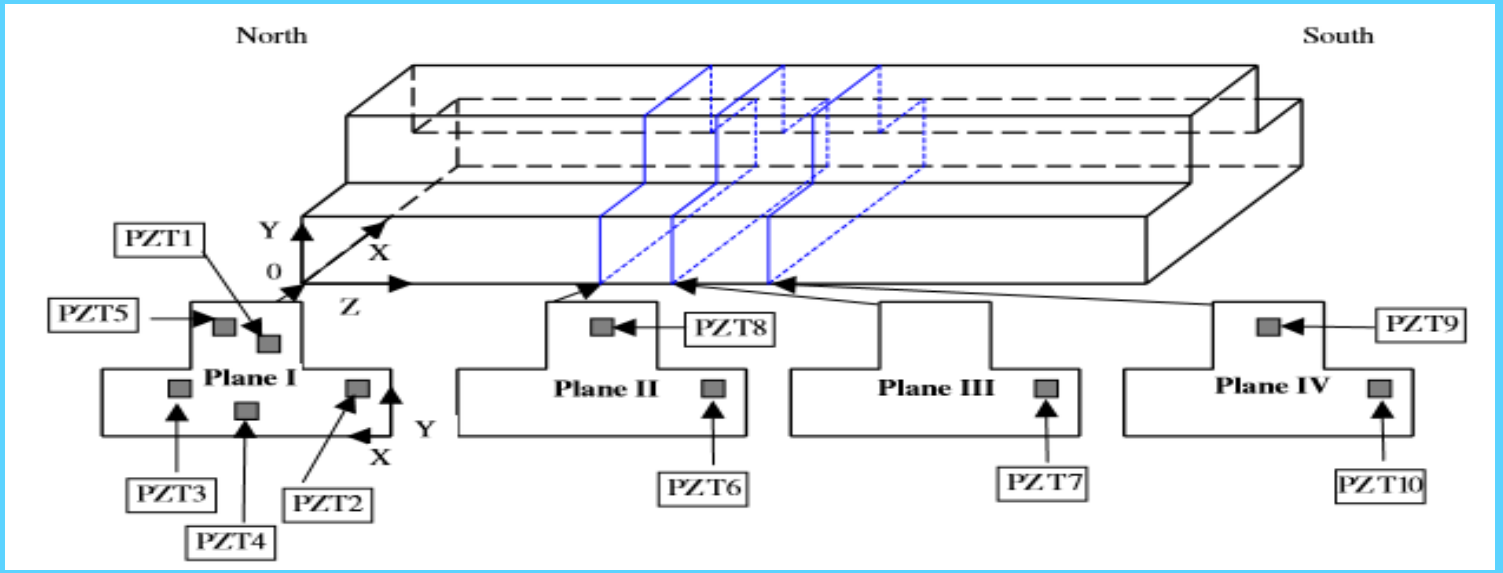


Source: Yan S. (2009)

Implantations of Sensors in Monitoring

The vibration-characteristic approach

utilizes piezoelectric actuators to generate certain waves, which propagate within the structure, and compares the structural vibration-characteristic parameters

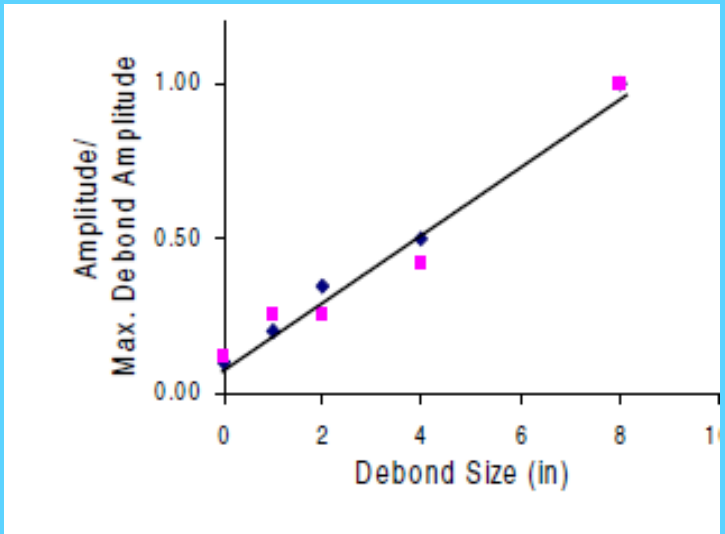


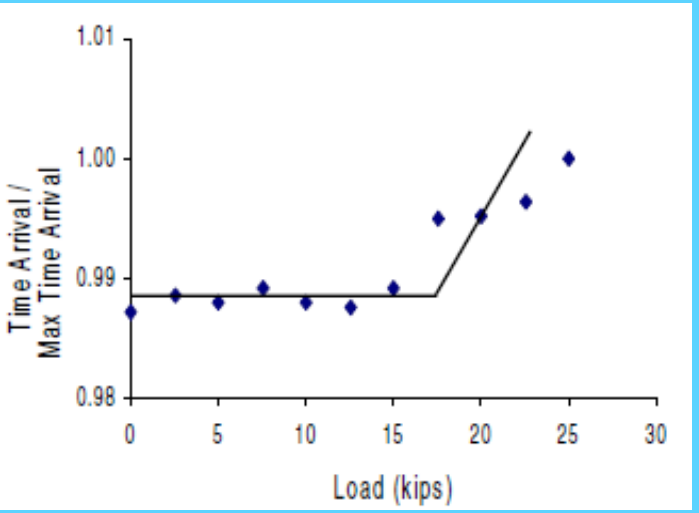
Yan S. (2009)

Implantations of Sensors in Monitoring

Lamb wave-based health monitoring approach

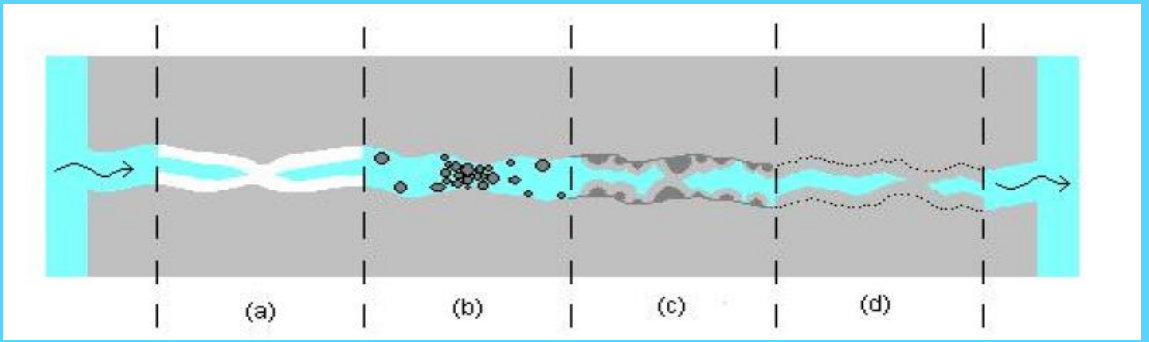
PZT patches either surface bonded to or embedded in the structure to detect structural damage by generating a Lamb wave and monitoring its reflections, Wang, 2001 Experiment.





Wang (2001)

SMART REPAIR MATERIALS



The bacteria, either *Bacillus pseudofirmus* or *Sporosarcina pasteurii*, are found naturally in highly alkaline lakes near volcanoes, and are able to survive for up to a staggering 200 years without oxygen or food. They are activated when they come into contact with water and then use the calcium lactate as a food source, producing limestone that, as a result, closes up the cracks

Jonker (2015)

Advanced Composite Materials

Temperature Effect on Repair of Shear Deficient Reinforced Concrete Beams Using (FRP) Materials

Beam Type	Original Shear Capacity (KN)	Repaired Shear Capacity (KN)	Shear Gain By FRP (KN)	Predicted Shear Gain by FRP (KN)	
				ACI (2008)	Fib (2001)
RB-inside -a	123	244	121	107	96
RB-inside -b	140	248	108	107	96
RB-outside -a	133	258	125	104	94
RB-outside -a	157	234	77	104	94

Weather Resistant Steels

Weather resistant steel is a low alloy steel that forms an adherent, protective oxide film of 'patina' that, in a suitable environment, seals the surface and inhibits corrosion. Such steels are specified to EN 10025-5 and have similar properties to conventional grade S355 steels to EN 10025-2. The most commonly used grade for bridgeworks is S355J2W+N.

Ref. Fosroc

University Maintenance Programs

UK: University of Birmingham

Post-Graduate Program: Road Management and Engineering

- The programme is relevant to conditions found in both developed and developing countries and are suitable for road engineers and civil engineering graduates who want to pursue a career in road management and maintenance.

- **Program content**
  - Road asset management
  - Road economics and financing
  - Pavement engineering
  - Sustainable road transport
  - Road design
  - Road safety
  - Rural roads

US: University of Wisconsin

Maintenance Management Certificate

University of Wisconsin College of Engineering offers cutting-edge short courses, certificate programs and licensing credits for today's working professionals.

Course: REPAIR OF CONCRETE, Outline:

- Achieving Durable Concrete
- Evaluating Concrete Condition
- Concrete Repair Materials and Their Properties
- Fundamentals of Concrete Repair
- Concrete Removal and Surface Preparation
- Concrete Structural Repairs
- Concrete Repair Specifications
- Protection Methods for Concrete
- Repair Methods for Concrete
- Repair Methods for Pavements, Sidewalks and Slabs on Grade
- Polymer Materials and Their Use in Concrete Repair

Canada: McGill University

CIVE 623 Durability of Materials (Graduate)CIVE 421 Municipal Systems (Undergraduate)

- Construction and maintenance of water distribution, wastewater and stormwater collection systems; pumps and pumping stations; pipe materials, network analysis and optimization; storage; treatment objectives for water and wastewater.
- **CIVE 469 Infrastructure and Society (Undergraduate)**
- Maintenance, rehabilitation and replacement issues; public and private sectors, privatization and governments; infrastructure crisis and new technologies; legal, environmental, socio-economic and political aspects of infrastructure issues; professional ethics and responsibilities; case studies.
- **CIVE 527 Renovation and Preservation: Infrastructure (Graduate)**
- Overview: Maintenance, rehabilitation, renovation and preservation of infrastructure;

Asia: University of Hong Kong

Green Facilities Management

- The course shall enhance classmates' engineering mindset in designing and performing maintenance activities and management in green facilities and related plants. The mindset shall cover analysis and synthesis of plant operations individually and also as entities in a system. The classmates shall utilize quantitative approach, qualitative approach and management rules to tackle problems. The manager so trained shall perform professionalism in achieving optimal benefits in green assets in a safe and effective manner.

Operation and maintenance of building and civil engineering works

- Policies, principles and practices in operation, maintenance and rehabilitation of buildings and civil engineering infrastructure such as: bridges, roadworks, marine and port works, water supply systems and sewerage schemes; and including aspects of: inspection, appraisal, materials repair methods, monitoring systems and forensic engineering.

Slope engineering

- Slope engineering in Hong Kong; geological models for slopes; slope stability analysis methods; landslip investigation; soil nailing; slope stabilization measures; surface drainage and protection; slope construction and monitoring; slope safety management and maintenance; natural terrain study.

South Africa: University of Cape Town

Post-Graduate Program: Civil Infrastructure Management and Maintenance, Repair & Rehabilitation of Concrete Structures

- Project Management & Systems Theory
- Project Planning & Implementation

Post-Graduate Program: Civil Infrastructure Management and Maintenance , Repair & Rehabilitation of Concrete Structures

Post-Graduate Program: Civil Infrastructure Management and Maintenance

- Elective Courses
  - Structural Concrete Properties & Practice

GCC: Saudi Arabia King Fahd University of Petroleum & Minerals

Master of Science in Civil Engineering Courses include:

1- CE 575 Pavement Evaluation, Maintenance and Rehabilitation.

- **Course Overview**: New concepts, methods and practices for the evaluation, maintenance, and rehabilitation of highway and airport pavement systems; non-destructive techniques for structural evaluation of pavements to assess performance; rehabilitation design; recycling and overlay design; quality control/assurance; computer applications in pavement evaluation and maintenance; selection of cost effective alternatives.

2- CE 672 Pavement Maintenance Management

- **Course Overview**: Techniques of network and project level pavement management; introduction to mapping/facility management system; field evaluation methods and equipment; performance modeling; maintenance and rehabilitation strategies; priority ranking procedures; overlay design procedures; maintenance specifications; computer applications in pavement management.

GCC: United Arab Emirat
UAEU

جامعة الإمارات العربية المتحدة
United Arab Emirates University
UAEU

Master of Science in Rehabilitation of Structures (CIVL616)

- Damage mechanisms, instrumentation and non-destructive test methods, conventional repair techniques, innovative repair and strengthening techniques with composites, case studies.

- **Advanced Materials in Construction**
  - Performance and properties of advanced construction materials (light weight aggregates, high performance Concrete, FRC, FRP modified asphalt, and metal). It covers corrosion protection systems of metallic structures as well as method of durability testing. It also addresses the environmental and economical considerations in

GCC: University of Sharjah

جامعة الشارقة
UNIVERSITY OF SHARJAH

B.Sc. in Civil Engineering

Elective course 040146X Special Topics in Civil engineering

This courses cover special advanced topics in civil engineering including buildings and structures maintenance.
External & internal causes that affect the durability of reinforced concrete structures and computation of corresponding service life.

- Corrosion of Steel Structures
- Diagnosis and In-Situ Testing of Reinforced Concrete
- Maintenance and Repair of Reinforced Concrete Structures
- Maintenance and Repair of Bridges
- Special Performance Concrete
- Case Studies

CENTER FOR INTELLIGENT MAINTENANCE SYSTEMS

The IMS Center is a leading NSF Industry/University Cooperative Research Center (I/UCRC) in the area of Prognostics and Health Management (PHM). The Center has over twelve years of experience in developing and delivering PHM solutions for a wide-range of applications. IMS Center's mission is to enable products and systems to achieve and sustain near-zero breakdown performance, and transform maintenance data into useful information for improved productivity and asset life-cycle utilization.

There are two types of IMS Membership: full and affiliate. Full members are companies or organizations with more than 500 employees and pay a membership fee of $40,000 annually; affiliate members have less than 500 employees and pay $12,000 annually. All members enjoy over a 30 to 1 leveraging ratio, and the opportunity to develop specific research projects with the center, based on their interests. Membership is the highest level of collaboration.

UK: University of Nottingham, NTEC and SUP&R ITN

SUP&R ITN
Sustainable Pavement & Railway Initial Training Network

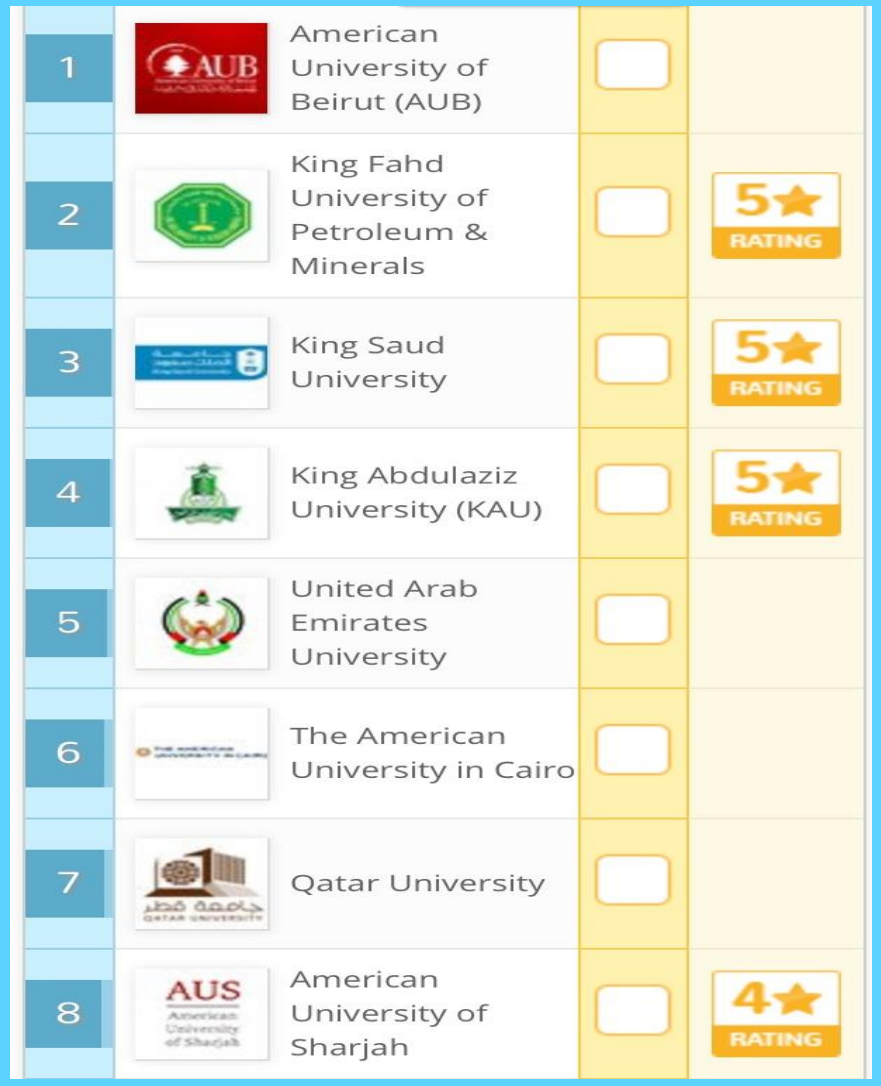
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

ESR7 : Optimisation of track bed design and maintenance

- Giacomo D'Angelo
- Supervisors: Nick Thom, Davide Lo Presti, Glen McDowel

- A Master designed and implemented in close cooperation between Politecnico di Torino and SUPSI
- Master requires full time participation between lectures (400 hrs) and stages for project Works (1200 hrs)
- Master is financed by companies (13.500 €) and participants (3.500 €)
- The **Master on Reliability, Maintenance and Safety** trains professionals able to intervene in the design and management of industrial plants, transportation systems and infrastructures.
- The formative course answers to the need of the Companies of employing neo-graduates with high potential, to be oriented towards RAMS Analyses in the design phases or towards Maintenance Engineering.
- The didactic methodology is strongly orientated to the formation on the field [the Master foresees 400 hours of theoretical formation

EDUCATION ROLE IN MAINTENANCE



1	American University of Beirut (AUB)		
2	King Fahd University of Petroleum & Minerals		5★ RATING
3	King Saud University		5★ RATING
4	King Abdulaziz University (KAU)		5★ RATING
5	United Arab Emirates University		
6	The American University in Cairo		
7	Qatar University		
8	American University of Sharjah		4★ RATING

1866
AUB
American University of Beirut
الجامعة الأميركية في بيروت

جامعة الشارقة
UNIVERSITY OF SHARJAH

جامعه الإمارات العربية المتحدة
United Arab Emirates University
UAEU

OBSERVATIONS AND RECOMMENDATIONS

Engineering Judgment

- is the vital tool in the assessment of the damages and causes of concrete deterioration and failure of structural elements
- Tests helps in visualizing the problem and making the decision. And what remains is an automatic implementation of repair methods and repair materials.

Prevent

- Done by:
- Periodical inspection
- Monitoring
- Routine maintenance

Pre-Design

- It would be of importance and good practice from the design stage to indicate the structural elements that will be exposed to severe environmental agents or special loading conditions and attention is given to special periodic inspection

The Goal?

- intelligent maintenance systems is to achieve and sustain the structures fully functional during their life cycle with self-maintenance capabilities

THANK YOU
FOR
YOUR ATTENTION