التقنيات الحديثة في صيانة الطرق والجسور

New Technologies in Road and Bridge Maintenance

January 23, 2020 – Riyadh, Saudi Arabia
PRESERVE YOUR CIVIL ENGINEERING STRUCTURES

Tomorrow’s maintenance: how innovations can help Civil Engineers?

DR MARC BROUXEL
Summer 2018

Vulnerable structures

Pont de l’Ile de Ré – Rupture of an external prestressed cable

Gennevilliers viaduct – Partial rupture of a reinforced earth abutment

Morandi viaduct – Sudden collapse
Summer 2018
Vulnerable structures

Pont de l'Île de Ré – Rupture of an external prestressed cable
Tomorrow’s maintenance: how innovations in auscultation can help Civil Engineers?

Could a failure occur on a civil engineering structure for which I am responsible?

Is my maintenance strategy effective?

Can I prove the relevance of my maintenance actions?
Tomorrow’s maintenance: how innovations in auscultation will help Civil Engineers?

Digitalization

Tailor made inspection

Use of drones and cameras

Monitoring

Engineering analysis: identify risky situations

Specific diagnosis

Modeling

Asset management optimization tools
Digitalization
Constitute a high definition digital twin
Digitalization
Constitute a high definition digital twin

Collect data
Data treatment
Data analysis
Digitalization
Collect data

Rotation axis

3 cameras
Vertical vision 150°
Resolution 4K/camera

3 depth sensors
Infra-Red sensor
Maximum distance 4m

Weight 3.1Kg

Autonomy 8h

Acquisition controlled on tablet
Scan: 30s
Digitalization

Data treatment

Displacement from one position to the other
Scan alignment
3D model
Digitalization

Data analysis: high-resolution photo survey of engineering structures (<1 mm)

3D reconstruction with photogrammetry
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Tailor made inspection

Today, owners have a much better view of their patrimony.

New tools are now available (new technics, new methods, ...)

Tailor made inspection

Inspection can be “tailor made” depending on the structures because it is possible to adapt the inspection methodology by combining different tools.

The inspection, and globally the maintenance policy must be tailor made to comply with the owner approach.
Tailor made inspection

Three levels of inspection can be defined, the objective being to give an indicator of the bridge degradation level:
- basic, visual inspection, with no access means to detect major problems
- Intermediate, hand on concrete with repair work definition
- Sophisticate (patrimony value, global network, speed of deterioration, impact of repair works on traffic, ...)

⇒ Adapt the inspection method to the owner policy and goals.

- What is the best type of inspection?
- What type and frequency of visit?
- Which quotation?
- Is this quotation discriminant enough to help me prioritize the actions?
Tailor made inspection

An example: joints on a strategic bridge
- Specific visit?
- Specific quotation?
Tailor made inspection

How to adapt the inspection policy?

Three possibilities:
- Type of visit
- Periodicity
- Execution
Tailor made inspection

How to adapt the inspection policy?

Three possibilities:
- Type of visit

<table>
<thead>
<tr>
<th>Pays</th>
<th>Type 1</th>
<th>Type 2</th>
<th>Type 3</th>
</tr>
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<tbody>
<tr>
<td>France</td>
<td><em>viste de contrôle</em></td>
<td><em>visite d'évaluation</em></td>
<td><em>inspection détaillée</em></td>
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<tr>
<td>Royaume-Uni</td>
<td><em>superficial</em> inspection</td>
<td><em>general</em> inspection</td>
<td><em>principal</em> inspection</td>
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<tr>
<td>Allemagne</td>
<td>superficial inspection</td>
<td>minor inspection</td>
<td>major inspection</td>
</tr>
<tr>
<td>Australie</td>
<td>routine inspection</td>
<td>comprehensive insp.</td>
<td>detailed inspection</td>
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</table>
Tailor made inspection

How to adapt the inspection policy?

Three possibilities:
- Periodicity

<table>
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<tr>
<th>Total Risk Score</th>
<th>Risk Rating</th>
<th>Recommended Principal Inspection Time Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0 \leq x &lt; 65$</td>
<td>High</td>
<td>6 years</td>
</tr>
<tr>
<td>$65 \leq x &lt; 75$</td>
<td>Medium</td>
<td>8 years</td>
</tr>
<tr>
<td>$75 \leq x &lt; 85$</td>
<td>Low</td>
<td>10 years</td>
</tr>
<tr>
<td>$85 \leq x \leq 100$</td>
<td>Very Low</td>
<td>12 years</td>
</tr>
</tbody>
</table>

Table 2 – Risk Ratings and Recommended Principal Inspection Intervals for Bridges and Large Culverts
Tailor made inspection

How to adapt the inspection policy?

Three possibilities:
- Execution
Tailor made inspection

How to adapt the inspection policy?

Three possibilities:
- Execution
Tailor made inspection

Your patrimony knowledge will define your inspection strategy.

Today the needs are more oriented towards global asset management and help decision tools.

The inspection policy can be adapted to the decided goals and the identified risk situations.

Many tools and technics are available. The surveillance can be adapted depending on the goals.
Tomorrow’s maintenance: how innovations in auscultation will help Civil Engineers?

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Use of drones and cameras

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Modeling

Asset management optimization tools
Tele Inspection: Drones and Cameras

3 steps to bring the asset in the office

SITE DATA ACQUISITION

PHOTOGRAMMETRIC PROCESSING

DIGITAL REPLICA

Realistic 3D Modelling

Ortho-images
High definition

On foot, or with a drone

Picture
Tele Inspection: Drones and Cameras

« Inspect remotely different parts of the structures and capture the degradation status of the facings »

A case by case solution for:

- Rapid intervention
- Remove inconvenience to operation
- Savings on access means
- Improve measurements reliability
Tele Inspection: Drones and Cameras

Inspect the arches and the underside of a bow-string on the Garonne river.
Tele Inspection: Drones and Cameras

Inspect the arches and the underside of a bow-string on the Garonne river.

Steel apparent
Length: 0.15m

Shine in formation
Surface: 0.5m²

Shine in formation

Cracks
Tele Inspection: Drones and Cameras

Inspect a deck with a camera mounted on a specific device
Tele Inspection: Drones and Cameras

Inspect a deck with a camera mounted on a specific device
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Monitoring

« Design and set up an instrumentation device to monitor in real time the behavior of sensitive structures and alert in case of anomaly »

- Understanding the real structural functioning of structures
- Detect the occurrence of damage
- Control the speed evolution of disorders
- Validate the readiness for service
Monitoring

A complete range of sensors (metrology and topometry)...

... to monitor on a real time basis, the behavior of:
- Span movement, flexion, vibration
- Supports settlement, shifting, scouring
- Environment Operating loads, soil behavior,
Cracks monitoring of the arch
Monitoring

Cracks monitoring of a viaduct piles
Monitoring

Real time wire break detection of post-tensionning cables with acoustic monitoring
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Engineering analysis: Identify risky situations

« Detect bridges and configuration at risk to guarantee the security of users and the availability of the structures »

- Identify the hazards
- Assess the vulnerability of the structures
- Examine the risks and take decision
Engineering analysis: Identify risky situations

« Detect bridges and configuration at risk to guarantee the security of users and the availability of the structures »

Typical Risk analysis
Using French administration methods

- Viaducts with prestressed beams
- Metallic structures
- Structures subjected to scours
- Structures and abutment in reinforced earth
- Structures in seismic areas

Customized risk analysis
using internal methods

- Global analysis of the asset
  - Vulnerability characterization
  - Identification of critical structures
  - Prioritization and risks treatment

- Specific detailed analysis
  - Identification of risky construction dispositions
  - Identification of sensitive equipments
Engineering analysis: Identify risky situations

Detecting structures with cornices presenting falling risks
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Specific diagnosis

Recognition of prestressed cable location by non destructive methods.
Specific diagnosis

Non destructive scanning of the concrete quality: for example lack of grout in PT ducts.
Specific diagnosis

Non destructive scanning of the concrete quality: for example lack of grout in PT ducts
Specific diagnosis

Non destructive scanning of the concrete quality: for example lack of grout in PT ducts
Specific diagnosis

Crossbow for the measurement of the residual tensile stress in cables
Specific diagnosis

Slotstress for the measurement of the residual tensile stress in structures
Specific diagnosis

Check the condition of the post-tension cables on Ile-de-Ré Viaduct
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- Digitalization
- Tailor made inspection
- Use of drones and cameras
- Monitoring
- Engineering analysis: identify risky situations
- Specific diagnosis
- Modeling
- Asset management optimization tools
Modeling to control the load capacity

« Modelize the structure and recalculate the loading capacity to evaluate the service level and the security level »

- Consideration of the real materials characteristics
- Recalculation of all type of structures (reinforced concrete, prestressed concrete, masonry, steel)
- Search of security reserves by calculation optimizations
Modeling to control the load capacity

Check the possibility of the passage of an exceptional convoy
Modeling to control the load capacity

Numerical modeling and dimensioning of reinforcements
Modeling to control the load capacity

Static and dynamic loading tests.
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Asset management optimization tools
3 key steps:

- Organize structural asset management
  - Inventory, locate and characterize the bridges
  - Prioritize their importance
  - Define the management indicators
  - Define the surveillance organization

- Build a financial strategy
  - Model and simulate the structures aging
  - Evaluate the budget needed to maintain the heritage
  - Optimize medium and long-term costs

- Schedule maintenance works
  - Estimate the costs of maintenance and repair works
  - Prioritize the actions to engage
  - Establish and optimize the multi-year maintenance program
Asset management optimization tools

A global approach:

- **CS** - Consulting Consulting to help managing the bridges
- **FS** - Financial software to help in decision making
- **AM** - Asset management digital platform
Asset management optimization tools

Personalized digital platform for the management of all the data and the management of maintenance actions

- Inventory / Geolocalisation / Data archiving
- Patrol / Annual control / periodic inspections
- Data visualization and dashboards
**Asset management optimization tools**

Financial software to help in decision making for long term investment planning in asset maintenance

Build your maintenance strategy by testing various scenarios:

- Input your objectives and budget limitations
- Plan and optimize investments
- Simulate future state of assets, maintained or not,
- Assess the costs of total or partial upgrade of assets group
Asset management optimization tools

Financial software to help in decision making for long term investment planning in asset maintenance

Explain and demonstrate the relevancy of your strategy

- Compare maintenance scenarios
- measure the effects in terms of improving the state of the park
- choose the optimal scenario
- export and exploit your data with Excel