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2nd Transnational Workshop duratiNET

DURATINET project presentation to French end users

Université de Bordeaux, Domaine du Haut Carré, Agora, 40 rue Pierre de Noailles,

Talence, France,

Steel maintenance and repair

by F. Schoefs

Institute for Research in Civil and Mechnical Engineering (GeM)

University of Nantes, France

European Union
European Regional Development Fund

Investing in our common future

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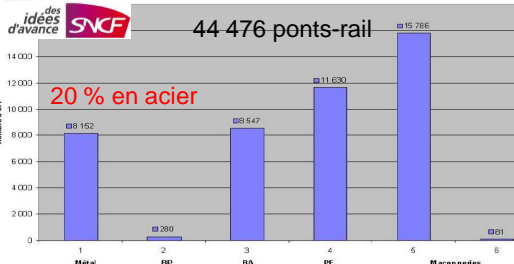
Enjeux et phénomènes de dégradation considérés:

- Endommagement (Fatigue)

attache longeron

Eymoutiers

- Corrosion - cause principale

CLASSEMENT PAR MATERIAU   PONTS RAILS > 2 M

des idées d'avance SNCF

44 476 ponts-rail

20 % en acier

1/3 agé de plus de 100 ans

CORROSION foisonnante

CORROSION OCCLUSANTE

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Enjeux et phénomènes de dégradation considérés:

106 km

40 % en acier

Répartition de l'âge des quais - Ports d'Etat (PM, PA & PIN)

Patrimoine en maçonneries

Patrimoine à forts enjeux (containers, hydrocarbures)

Projet GEROMP – Oxand

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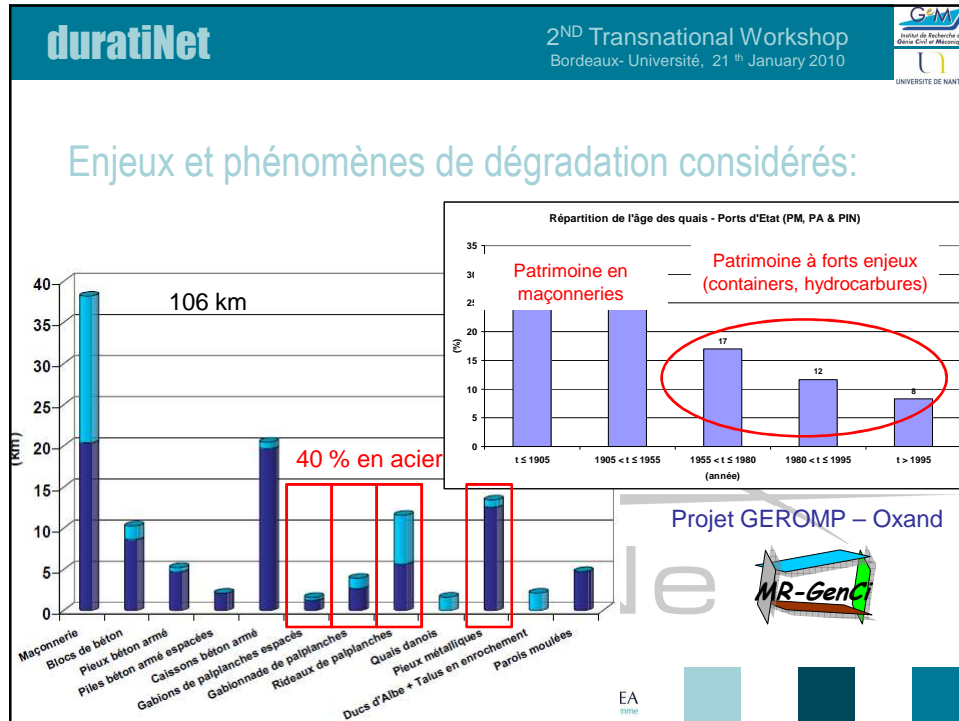
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Case of suspension-bridges : why ?

The corrosion process in cables is very hard to model
because :

- It is affected by a lot of time-variant and space-dependent factors :
    Temperature, Wind, Humidity.
- The number of fibers in cables is huge.
- On-site measurements are costly and difficult to realize.

→ Need to gather data in a well documented data base and quantify the performance of NDT-tools.

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Case of metallic (rail-)bridges : why ?

The fatigue process in beams is very hard to model / the structural modelling is feasible.

Real challenges:

- Increasing the use of rail for european transport: up-dated reliability target ?

- Inspection of cracks is difficult (see ICON / MITKI projects).

→ Need to gather data in a well documented data base. Include existing models (Yotte et al.) in a maintenance flow-chart.

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Case of habour structures : why ?

The corrosion process is very hard to model because :

Sheet-piles wall

- It is affected by a lot of time-variant and space-dependent factors : Temperature, Dissolved Oxygen, Salinity, Tide level, Suspended materials (bio-corrosion), pollution, water flow/waves, abrasive materials.

- Only few on-site measurements are available and not always well documented (context).

- On-site measurements are costly and difficult to realize.

On-pile wharf

→ Need to gather data in a well documented data base

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Why ageing models are required ?

- to optimize inspection and repair planning **with time**.

Loss of thickness in the tidal area

With bio-corrosion

Without bio-corrosion

2 years   30 years Time

But difficult to inspect : what it seen ?

Loss of thickness with depth (20 yrs)

Bending moment with depth

- to optimize inspection and repair planning **with space**.

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Impact de la corrosion sur le comportement mécanique du quai

Zone aérienne

Zone d'éclaboussures

Zone de marnage

Zone basses eaux

Zone immergée

Zone de boues

Sol de fondation

Moment fléchissant

Corrosion

Corrosion

①

IMdR 09– Cachan, France – 13 octobre 2009

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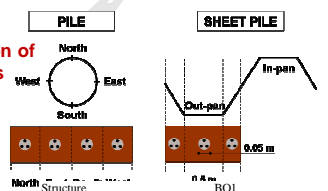Transnational Programme

24/01/2010

Slide 1

French experience

- Guidelines are published by the government (not rules), but too expensive ← feedback of owners
- Data are available
(100 000 measurements)
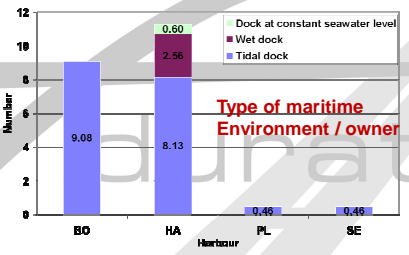- The data base is now documented

Nb and location of measurements

| PILE | SHEET PILE |

North
West — East
South
In-pan
Out-pan
0.05 m

Chemical characteristics

Type of maritime Environment / owner

Bar chart legend:
- Dock at constant seawater level
- Wet dock
- Tidal dock

Values: BO 9.08, HA 8.13 (2.56, 0.60), PL 0.46, SE 0.46
Harbour

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| Structure | | BO1 | | | |
| | | | HA7d & HA8b | | |
Parameter	Mean	Min	Max	Mean	Min	Max
Temperature (°C)	7.2	19.5		13.3		
	20.7			13.7	8.1	
pH	7.8	8.1		8.0		
	8.5			8.1	7.7	
Conductivity (mS/cm)	37.2	49.0		46.8	50.5	
Salinity (g/l)	25.4	33.7	41.4	31.5	33.7	
		32.9		27.7		
O2 (mg/l)	11.2	23.9		8.7	6.4	
		8.7		6.9	11.0	
SM* (mg/l)	8.3	9.9		4.7	17.7	
		3.3	15.0			

Slide 2
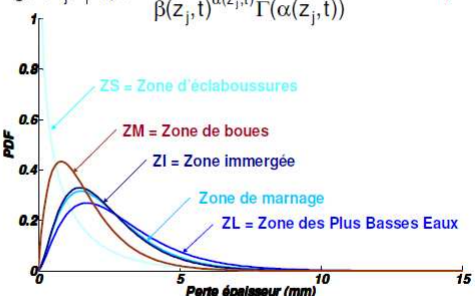
French experience

- Model are emerging (Medachs & Gerom projects)

Zone aérienne
Zone d'éclaboussures
Zone de marnage
Zone basses eaux
Zone immergée
Zone de boues
Sol de fondation

Loi de probabilité Gamma de paramètres α et β :

$$f_C(c, z_j, t | \alpha, \beta) = \frac{1}{\beta(z_j,t)^{\alpha(z_j,t)}\Gamma(\alpha(z_j,t))} c^{\alpha(z_j,t)-1} \exp^{\frac{c}{\beta(z_j,t)}}$$

ZS = Zone d'éclaboussures
ZM = Zone de boues
ZI = Zone immergée
Zone de marnage
ZL = Zone des Plus Basses Eaux

PDF vs Perte épaisseur (mm)

Distributions de la perte d'épaisseur d'acier au temps t = 25 ans

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French experience

$C_{0,95} = 6,5$ mm
$C_{0,95} = 7,0$ mm

Perte d'épaisseur (mm)

- Sols non remaniés (EC3-P5)
- Eau douce (EC3-P5)
- Eau douce très polluée (EC3-P5)
- Eau de mer (ZL & ZS) (EC3-P5)
- Eau de mer (ZT & ZI) (EC3-P5)
- Façade atlantique (Cetmef)
- Façade méditerranéenne (Cetmef)

$C_{0,50}$
$C_{0,50}$

$C_{0,05} = 1,0$ mm
$C_{0,05} = 0,5$ mm

Comparaison avec les préconisations des règlements de calculs

Surépaisseurs sacrificielles d'acier en fonction de la durée de service d'un ouvrage pour une seule face exposée d'après l'Eurocode 3 et le CETMEF

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La problématique de l'inspection …

… en quelques mots

Erreur de mesure = f(z)

- Zone aérienne
- Zone d'éclaboussures
- Zone de marnage
- Zone basses eaux
- Zone immergée
- Zone de boues
- Sol de fondation

Corrosion

E(C)ᵢ

NDT (T1-D1)   NDT (T1-D2)   NDT (T2-D1)   NDT (T2-D2)

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To be made : objectives of Duratinet

- Share Practices, model, methods and data in the Atlantic area
- Provide guide-lines based on risk analysis in view to optimize the number of measurements at each inspection time and the number of inspections (in link with WG2)

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Complete the knowledge :
specimens on site (documented)

Mapping of corrosion
(Gabion type)

Corrosion rate

Data analysis
(residual
thickness –
ROC)

MEDACHS

ESPAÑA ESPACIO ATLÁNTICO
FRANCE ESPACE ATLANTIQUE
IRELAND ATLANTIC AREA
PORTUGAL ESPAÇO ATLÂNTICO
U.K. ATLANTIC AREA

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To be made : objectives of Duratinet

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- Provide guide-lines based on risk analysis for the maintenance (painting) **NEW** : feedback is essential (if documented) : environmental conditions during painting works / type of product ...

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Results of Medachs project

MEDACHS

- rank 5 main coating products performance

Zinc polyurethane Mono-component + mixed resin « polyurethane + hydrocarbon »

| ------- : Bad |
| ------- : Medium |
| ------- : Good |

Epoxy coating

Epoxy-polyamide or polyester coating + flakeglass

Limit States D(d(xi)) < 0

Fixing (4 months)	Paint 1	Paint 2	Paint 3	Paint 4	Paint 5
Visual aspect (10 months)	Paint 1	Paint 2	Paint 3	Paint 4	Paint 5
Porosity (10 months)	Paint 1	Paint 2	Paint 3	Paint 4	Paint 5

Pb : head of pile

CeTe
Nord Picardie

Centre d'Études Techniques de l'Équipement

PORT ATLANTIQUE
Nantes Saint-Nazaire

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- Provide guide-lines based on risk analysis for the maintenance (painting) NEW : feedback is essential (documented) : environmental conditions during painting works / type of product …
- Provide data base for measurement of NDT tool performance on site. Developp the use of connex data : video-tapes before painting. **NEW**

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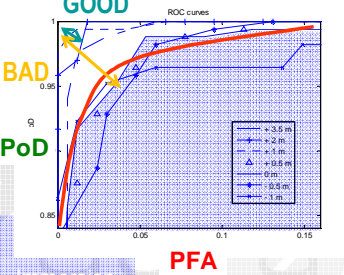2ND Transnational Workshop
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MEDACHS

Results of Medachs project
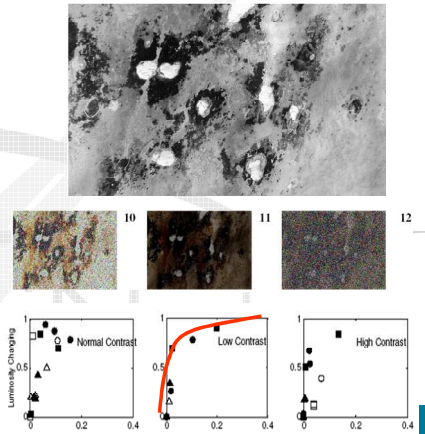
Uniform corrosion
(from data in Brest, Nantes, Boulogne)

Localized corrosion
Theoretical work

ROC plot (thickness)

GOOD

BAD

PoD

PFA

Immersion Area

ROC plot (area, maximum axis)

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To be made : objectives of Duratinet

The ESSENTIAL role of end-users :

- Maintenance policy (repair during winter for touristic equipments)
- Feedack about products/protocols (complicated or not)
- Benchmark structures with real stakes.

Thank you !

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