



COURSE
Testing techniques for structures inspection **29th and 30th May 2012**

Ground-Penetrating Radar Covermeter

- Fundamentals
- Equipments and handling
- Test procedure
- Processing
- Particular case

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Ground-Penetrating Radar (GPR)



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Kind of Devices

IFSTTAR

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GPR profile

Principle

- Variable velocities
- Unknown attenuation
- Large radiation pattern

- => Calibration
- => depth penetration ?

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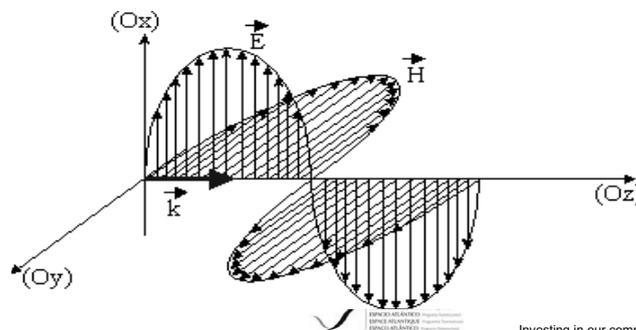


EM propagation theory

4 Maxwell eqs => 2 Propagation equations (\vec{E} , \vec{H})

Elementary solution : Plane wave which velocity is $v \sim c/\sqrt{\epsilon' r}$

- C : light velocity - 30 cm/ns
- • : dielectric constant (permittivity)



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EM parameters

- Permeability :

Defined by the polarisation reacts under magnetic field.

Non magnetic ~ vacuum

$$\mu = \mu_0 = 4\pi 10^{-7} \text{ H/m}$$

- Conductivity :

Define a medium with free electrons (induce EM attenuation)

- Permittivity :

Defined by the polarisation reacts under electric field.

=> Relative permittivity

$$\epsilon_r = \frac{\epsilon_{eff}}{\epsilon_0}$$

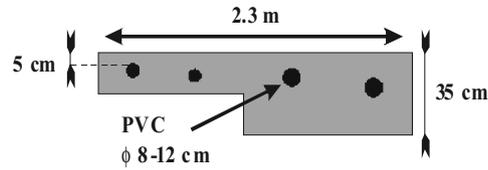
	Permittivity	Velocity (cm/ns)
air	1	30
water	~80	3.3
Fresh concrete	13-16	~ 8
Dry concrete	4-6	~ 13



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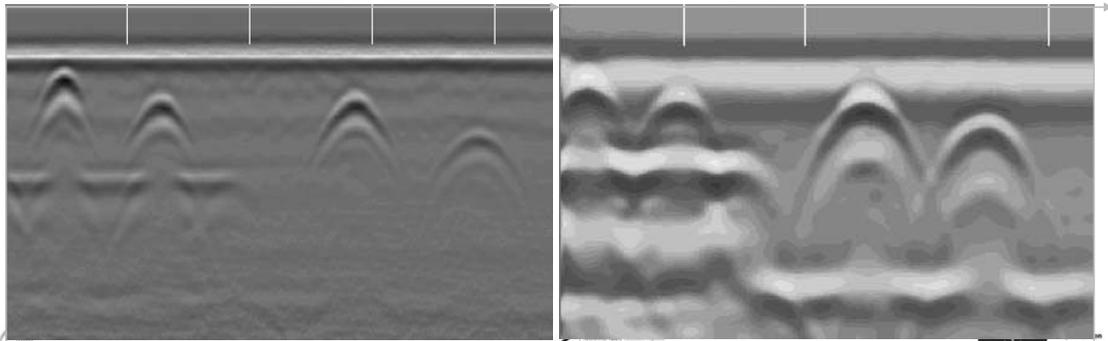


Frequency - Resolution

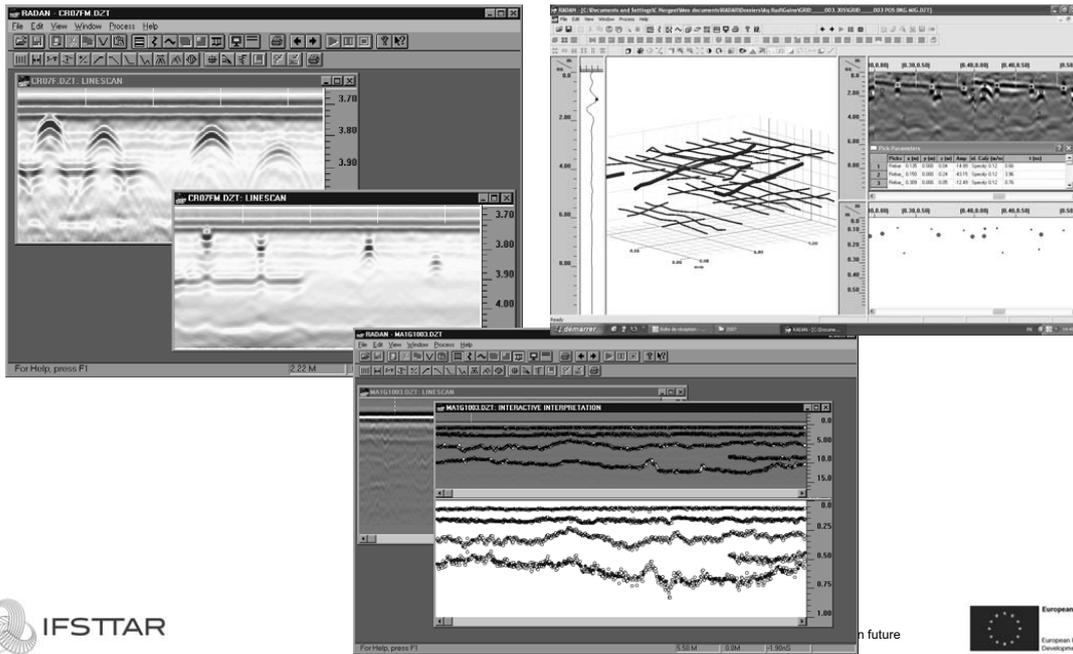


(antenna 1.5 GHz)

(antenna 900 MHz)



GPR processing



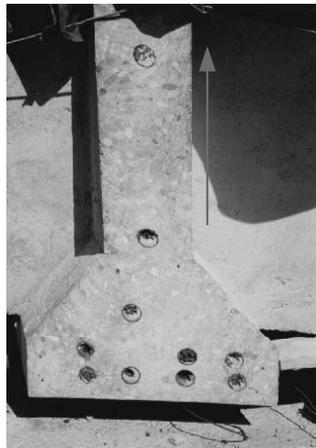


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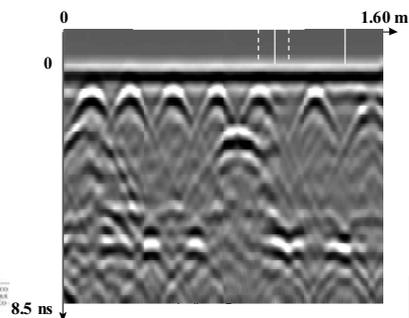
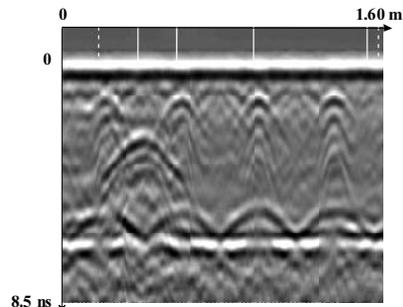
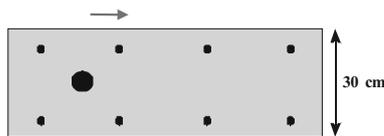
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RC structures



Pos-tensioned beam

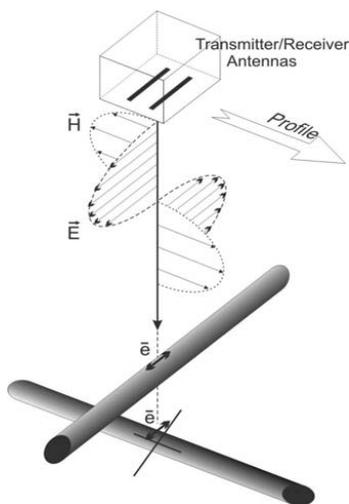


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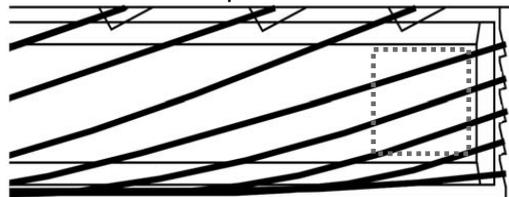
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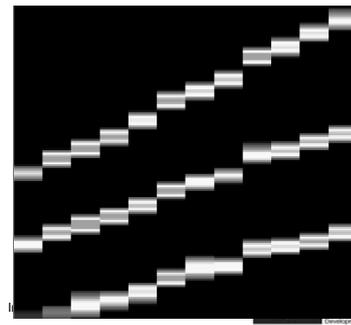
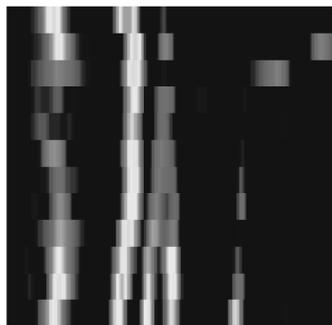
GPR mapping



Tested area on post-tensioned beam

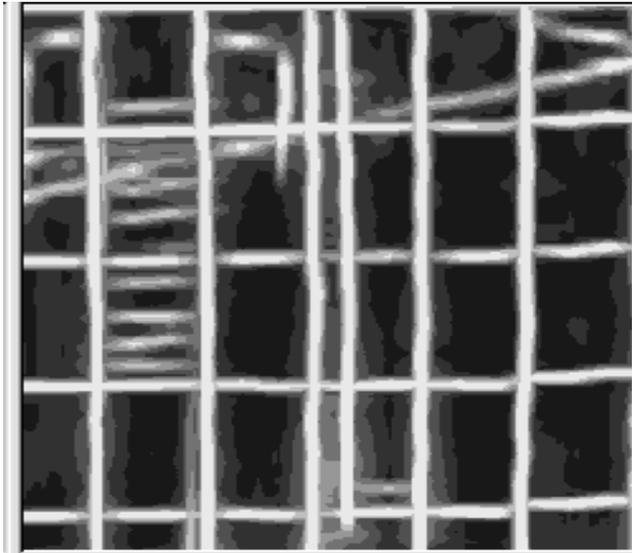


Polarisation effect

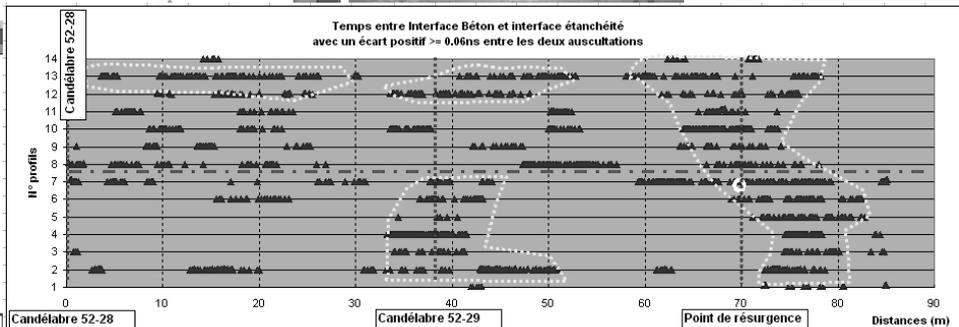
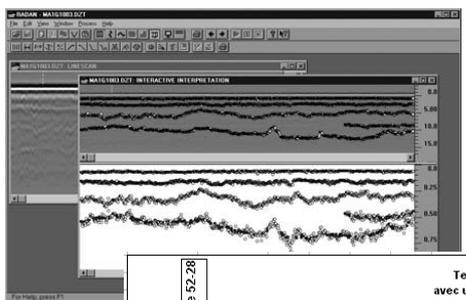




GPR mapping



Sealing evaluation (R&D)





Covermeter

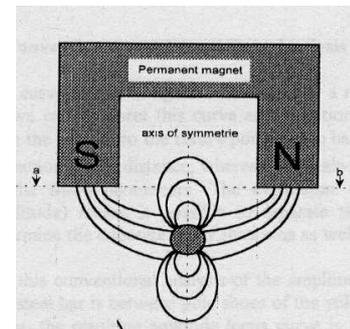
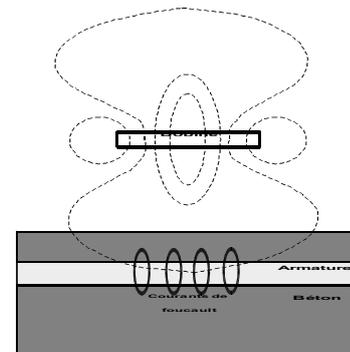


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Principle

- Low-frequency EM
(covermeter, profometer...)
- Magnetic
(Ferrosan...)
- Applications
 - Rebars location
 - Cover-concrete estimation
 - Rebar diameters

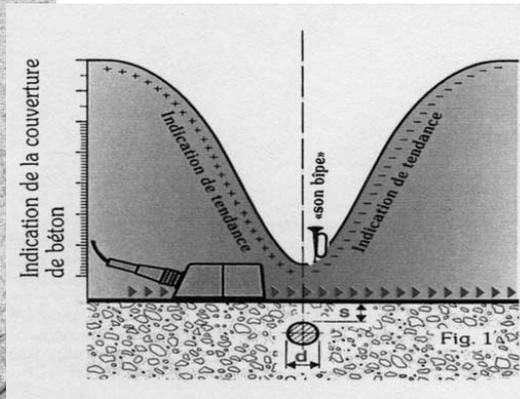
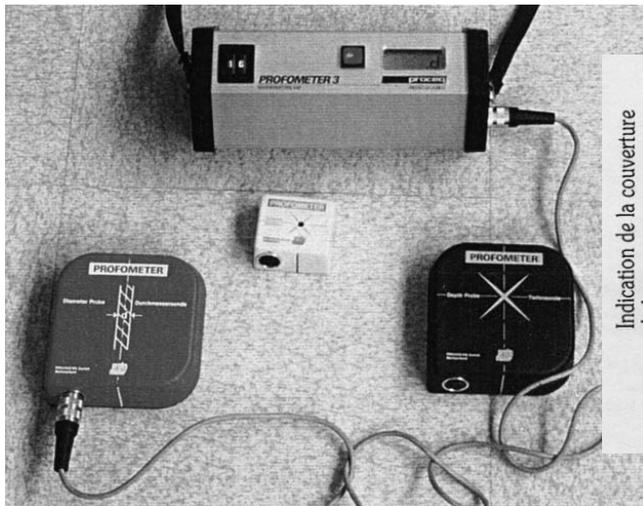


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Profometer 3 (ex)



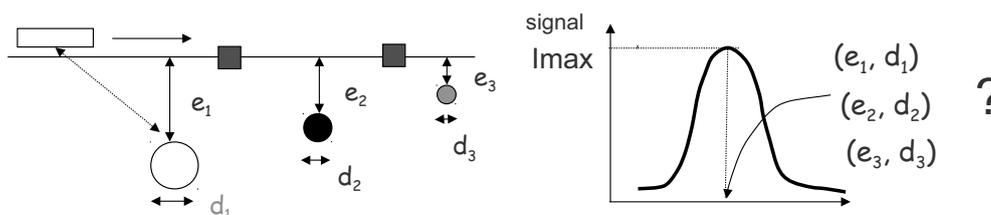
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Principle

- Cover-concrete estimation (error) - hyp: diameter known

Conditions	Up to 2 mm (5%)	Up to 3 mm (8%)	Up to 5 mm (15%)	Above
Laboratory	Necessary	Non-acceptable	Non-acceptable	Non-acceptable
Favorable sites	Good	Expectable	Weak	Non-acceptable
Averages sites	Excellent	Good	Acceptable	Non-acceptable



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Diameter estimation

Direct Meas. Spaced Meas.

Spacing tool (3cm)

With spacing tool

Without

Real cover

Real diam.

signal I_{max}

(e_1, d_1)
 (e_2, d_2)
 (e_3, d_3) ?

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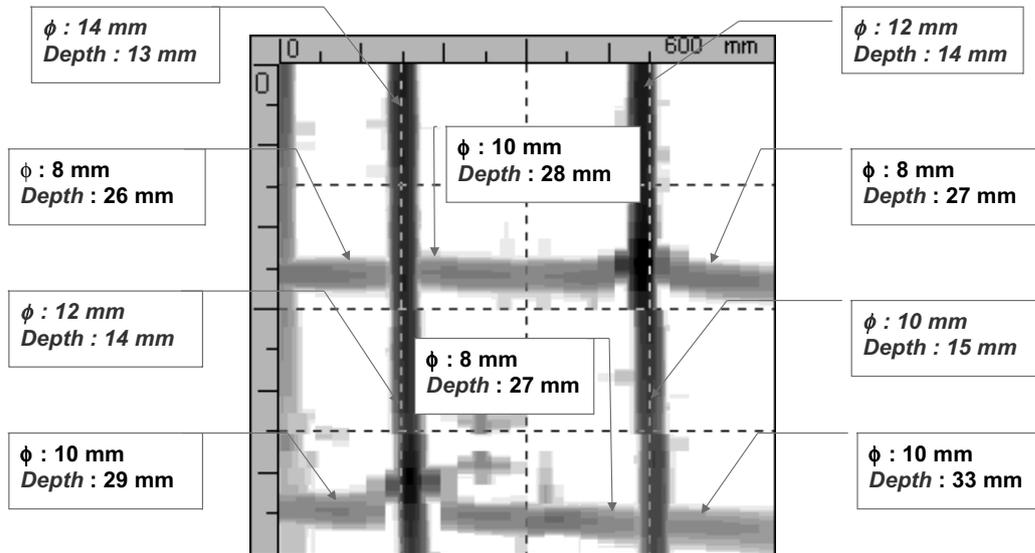
Ferroskan Results (ex)

- 7 cores
- 2 acquisitions (location / image)
- Images 60*60 cm
- Post-processing

IF



Ferroskan Results (ex. 2)



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Thank you



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