

IMGC

L'INSTRUMENTATION AU SERVICE DES OUVRAGES DE GÉNIE CIVIL

Journée Technique

MARDI 13 JUIN 2023

FNTP – 3 Rue de Berri, 75 008 PARIS

Modélisation physique et numérique des mécanismes de transfert de charge des fondations des éoliennes terrestres

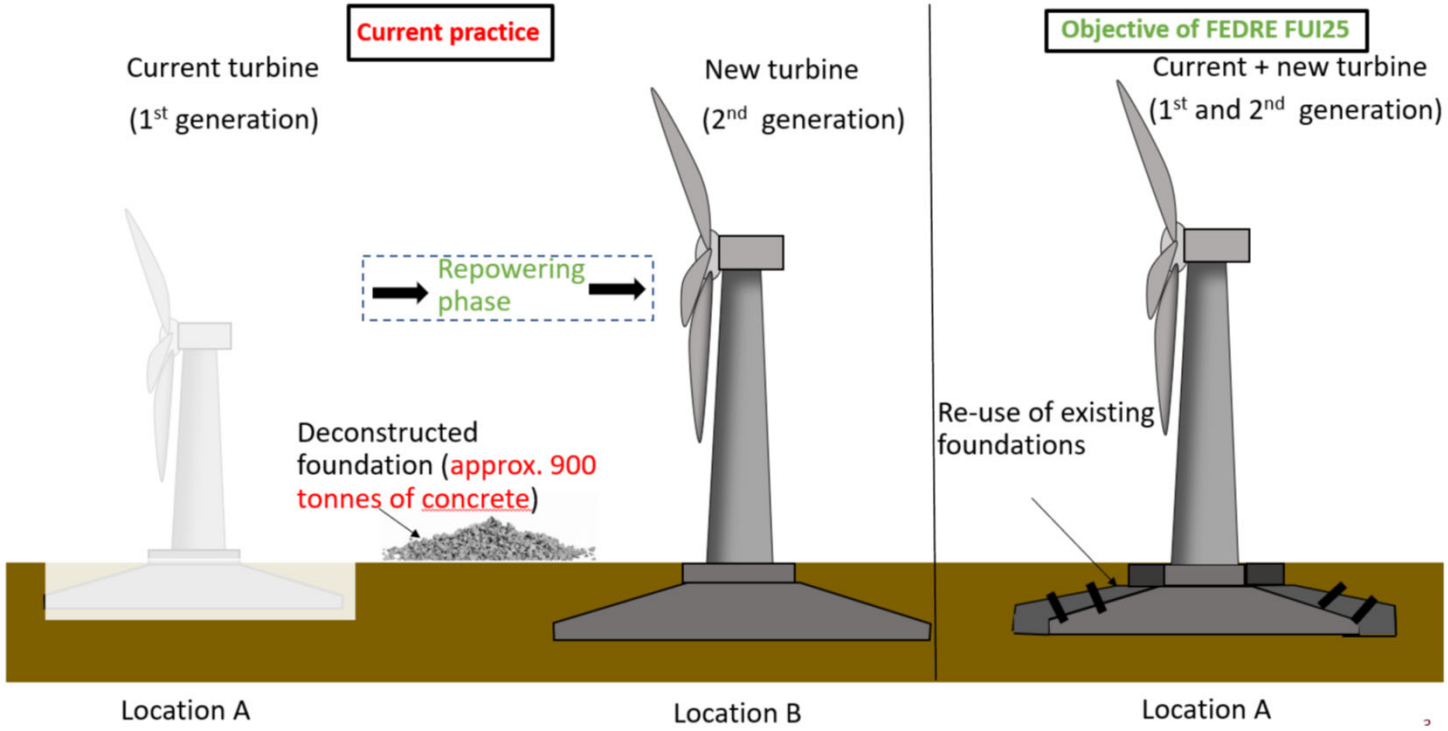
Janet MODU – ANTEA GROUP
Laurent BRIANÇON – INSA LYON
Charles NADIM – ANTEA GROUP

Quelle instrumentation, pour faire quoi ?

1. Le projet FEDRE
2. Instrumentation d'une fondation réelle
3. Instrumentation d'un modèle réduit
4. Apprentissages

1- Le projet FEDRE

Objectif



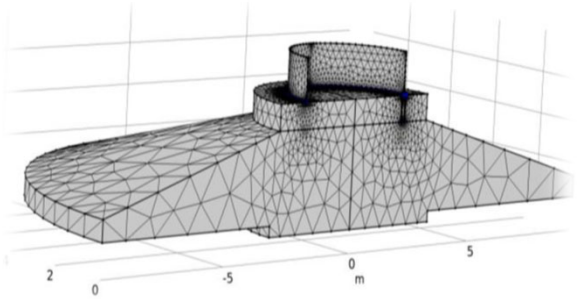


1- Le projet FEDRE

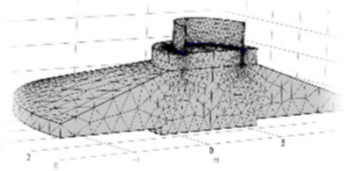
Méthodologie



Structural Health Monitoring



Modélisation numérique échelle réelle

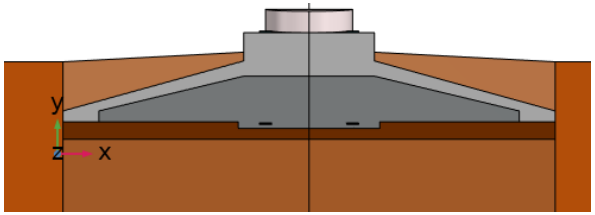


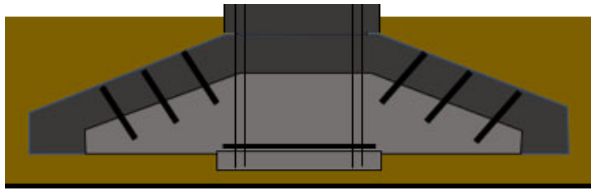
Modélisation numérique au 1/10



Modèle physique au 1/10

Modélisation numérique de la solution

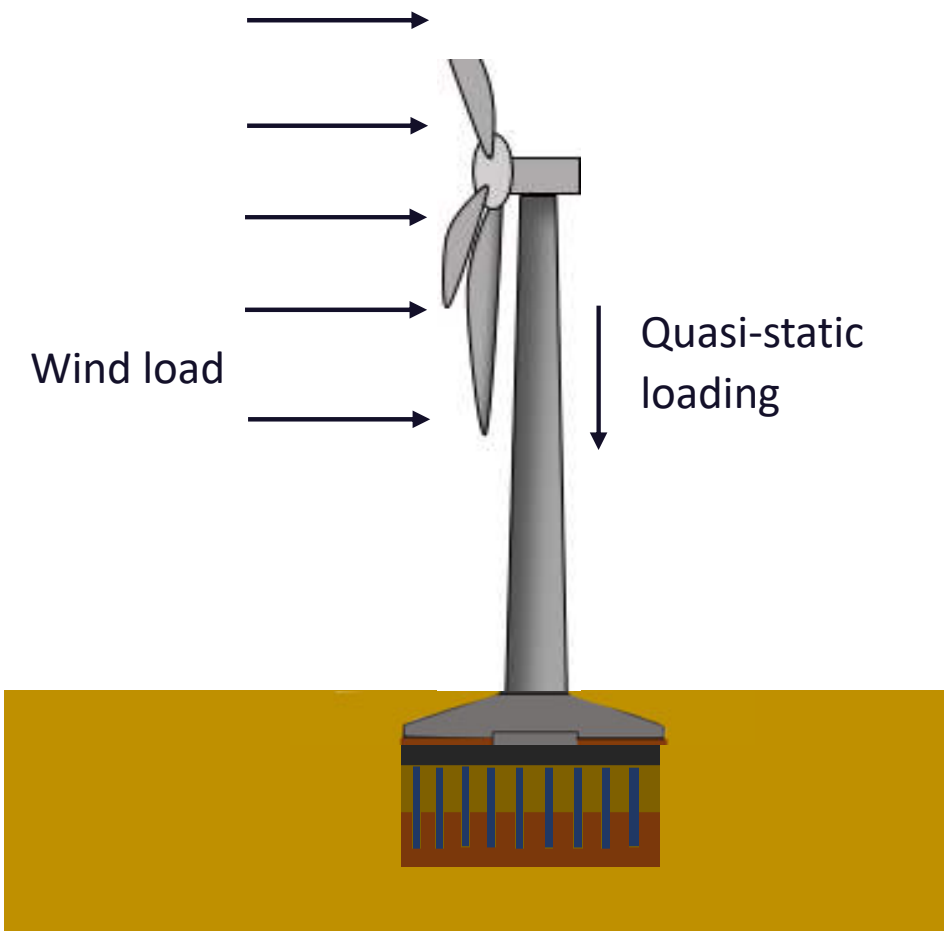


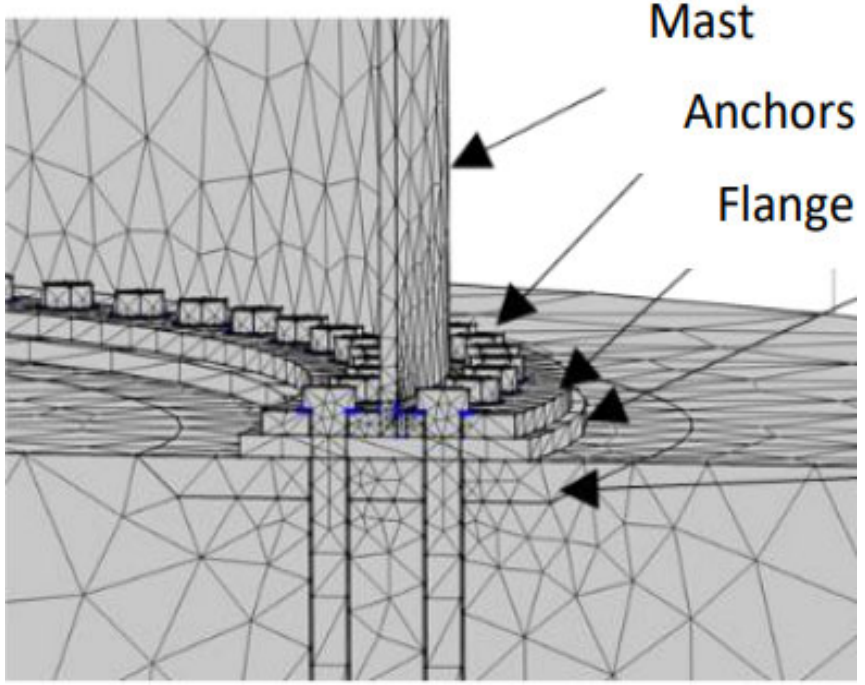


Modèle physique de la solution

1- Le projet FEDRE

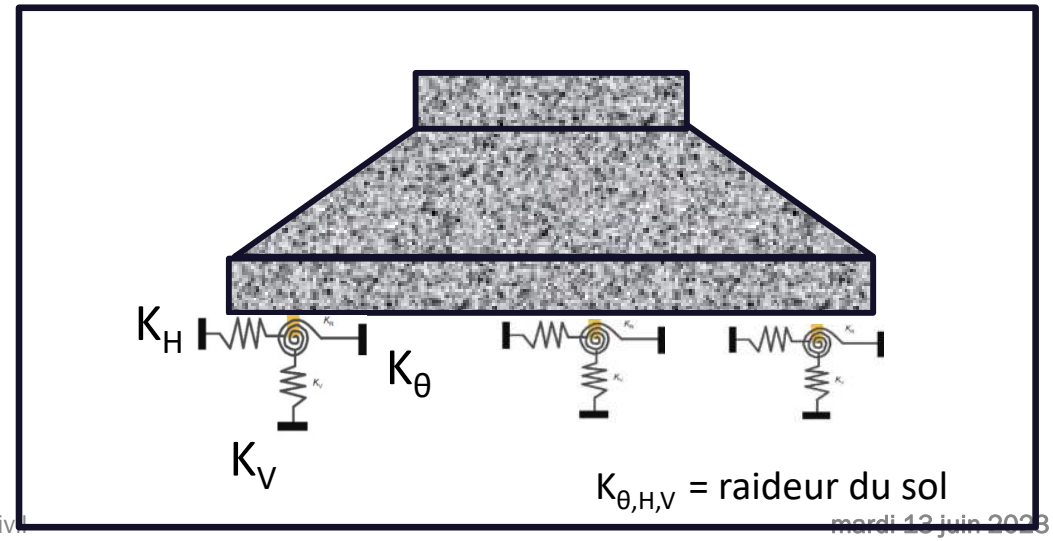
Mécanismes et interactions





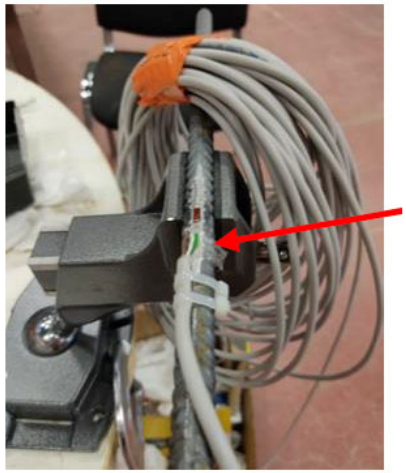
Anchor cage

High strength mortar

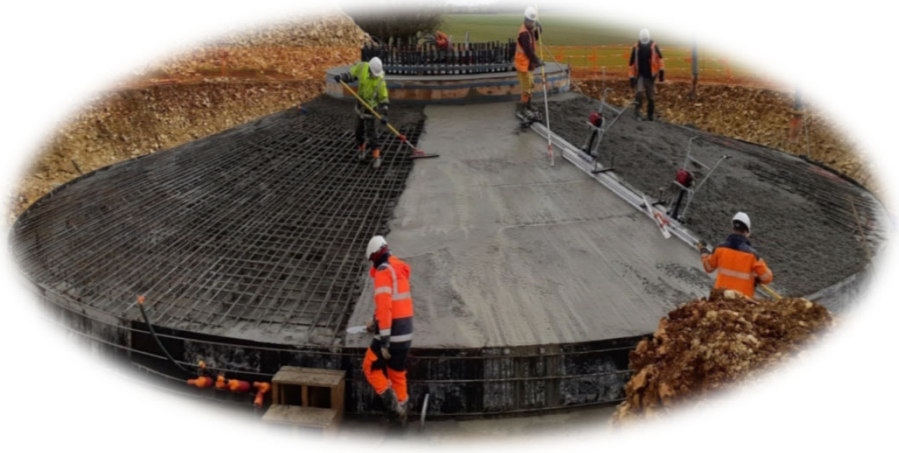


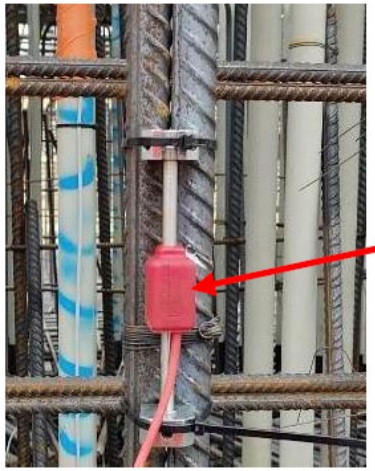
2- Instrumentation d'une fondation réelle

Ecoust-St-Mein (62)



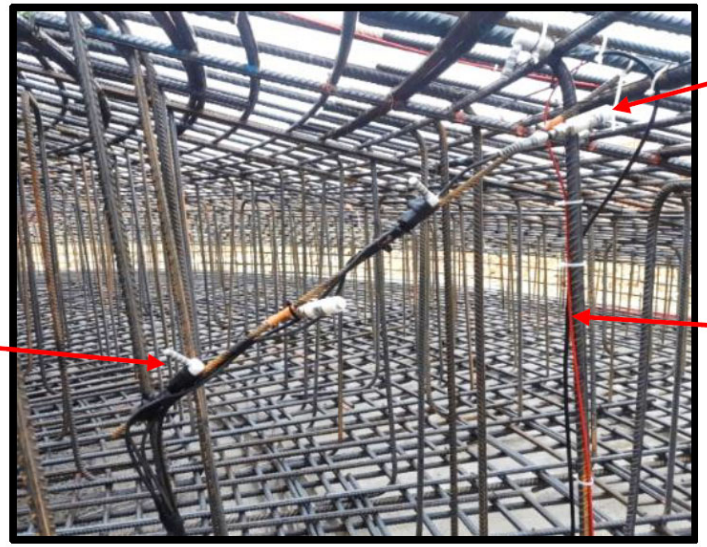
Electrical
Resistance
Strain gauge

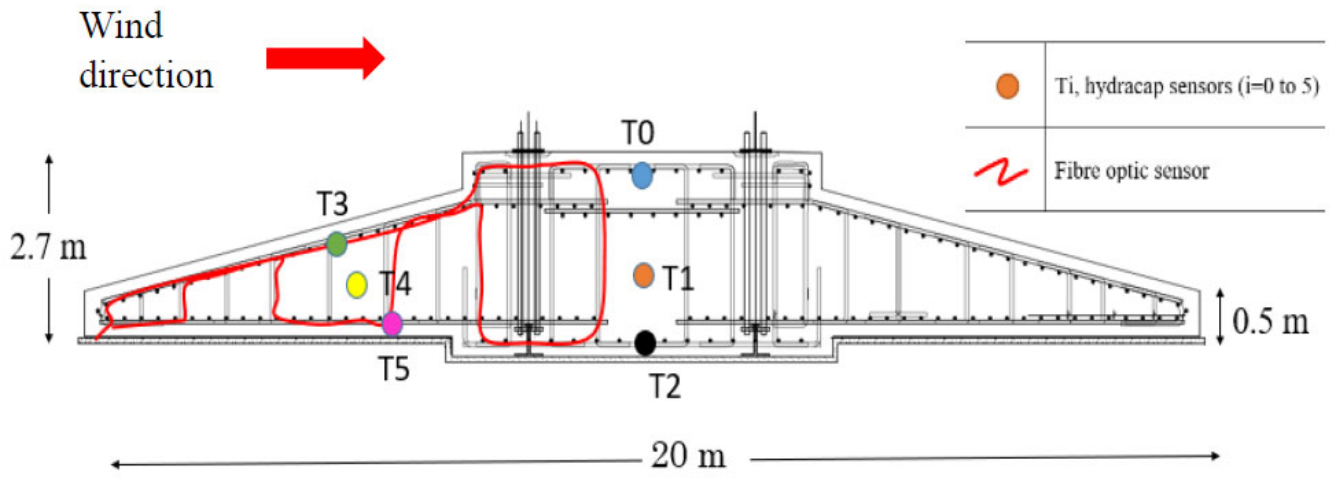




Extensometer

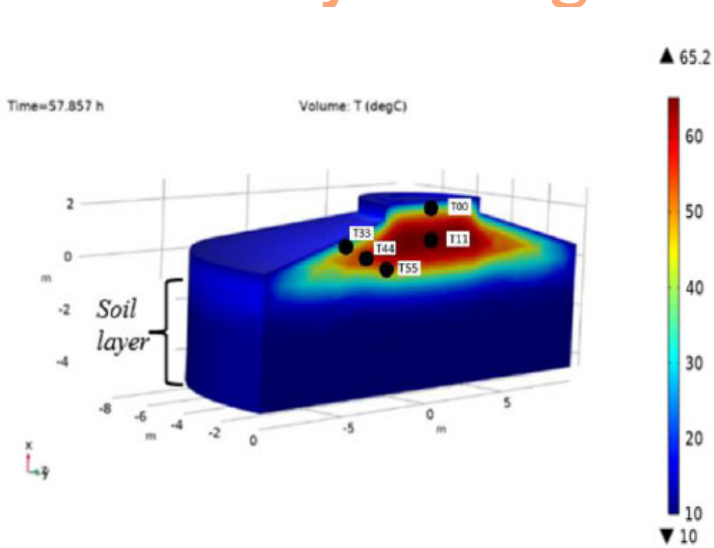
2- Instrumentation d'une fondation réelle

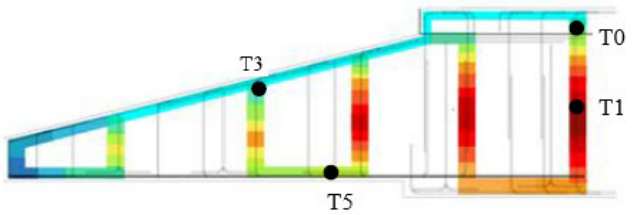


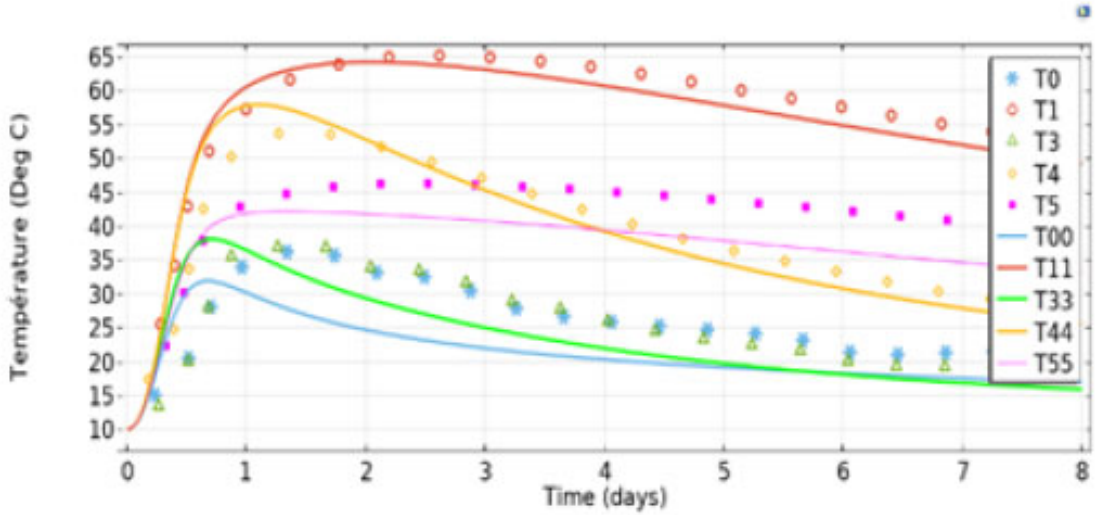


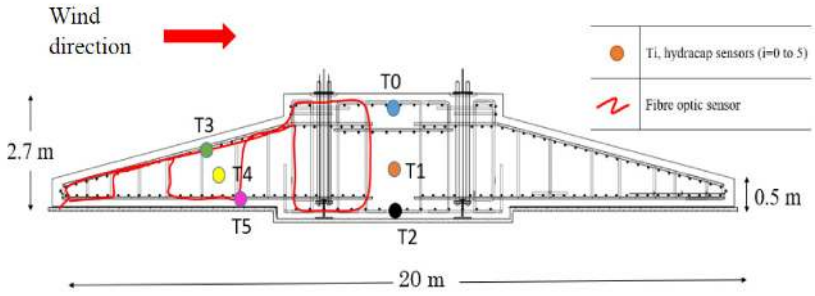
2- Instrumentation d'une fondation réelle

Températures au jeune âge



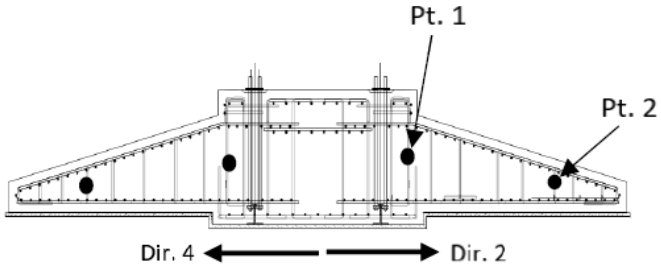


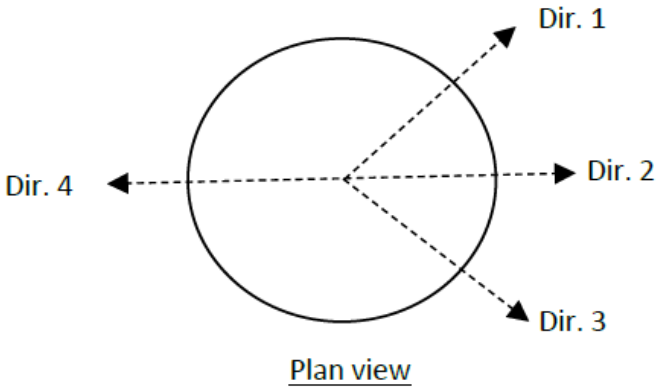


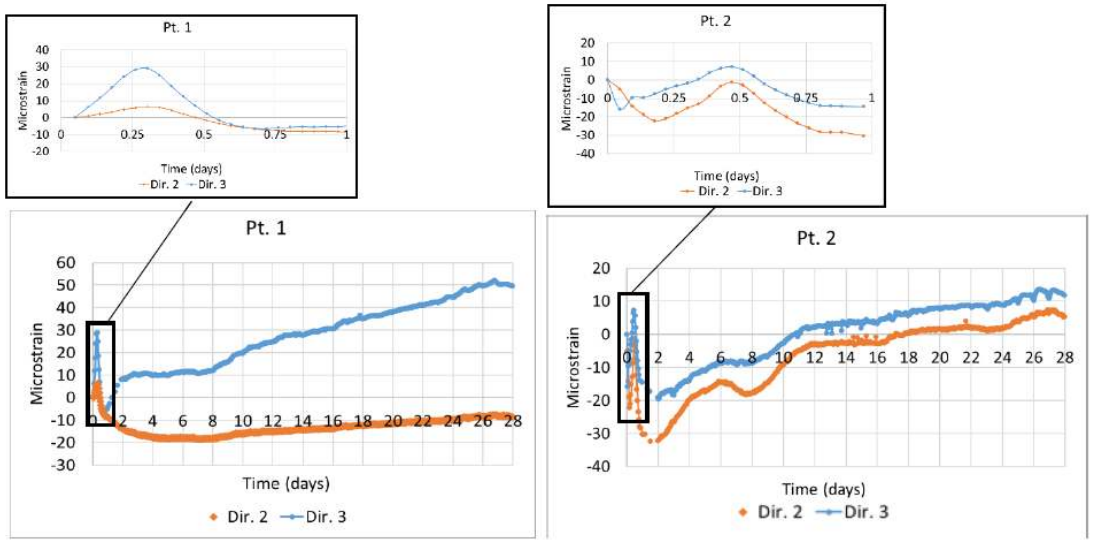


2- Instrumentation d'une fondation réelle

Déformations au jeune âge

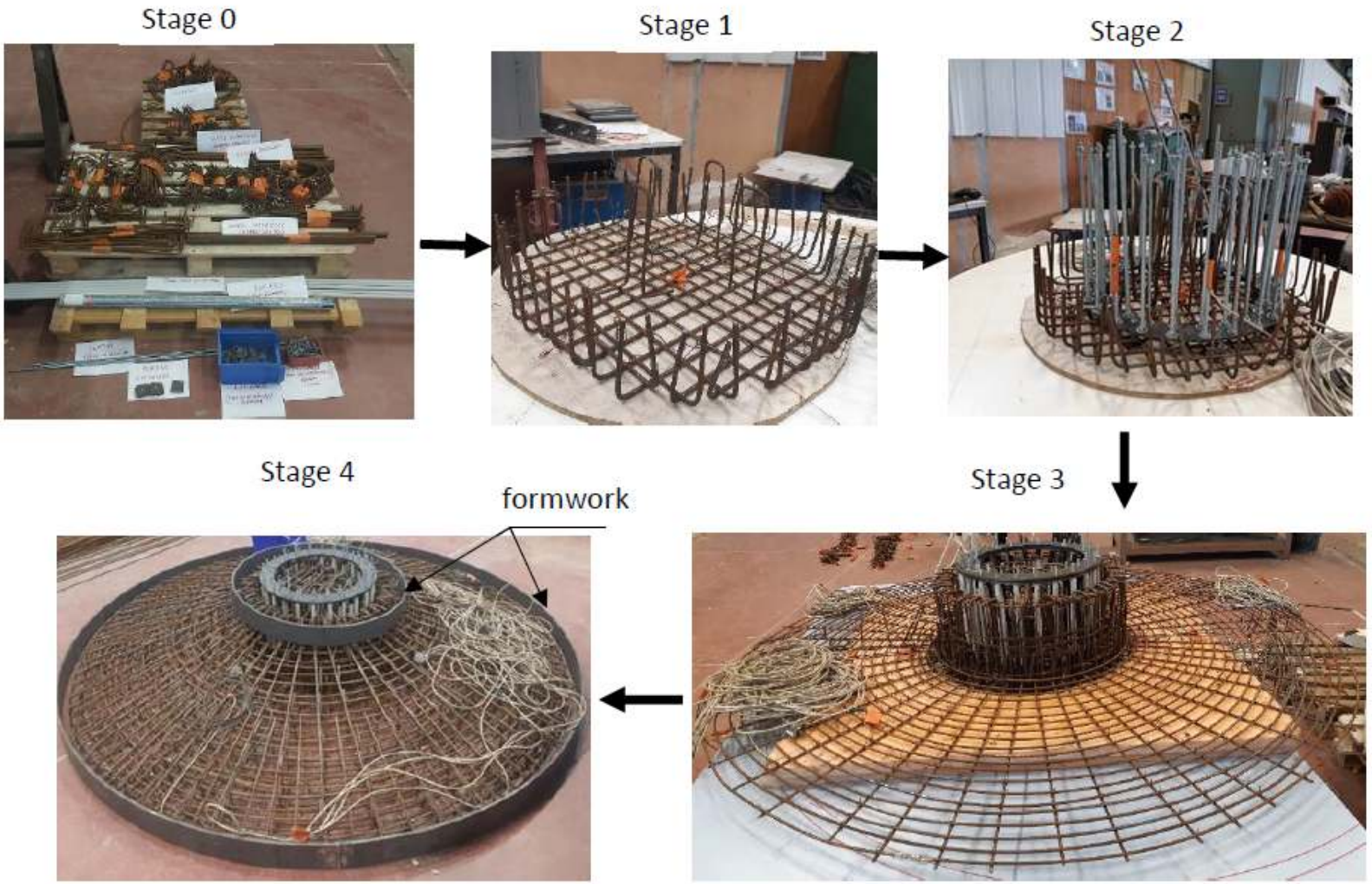






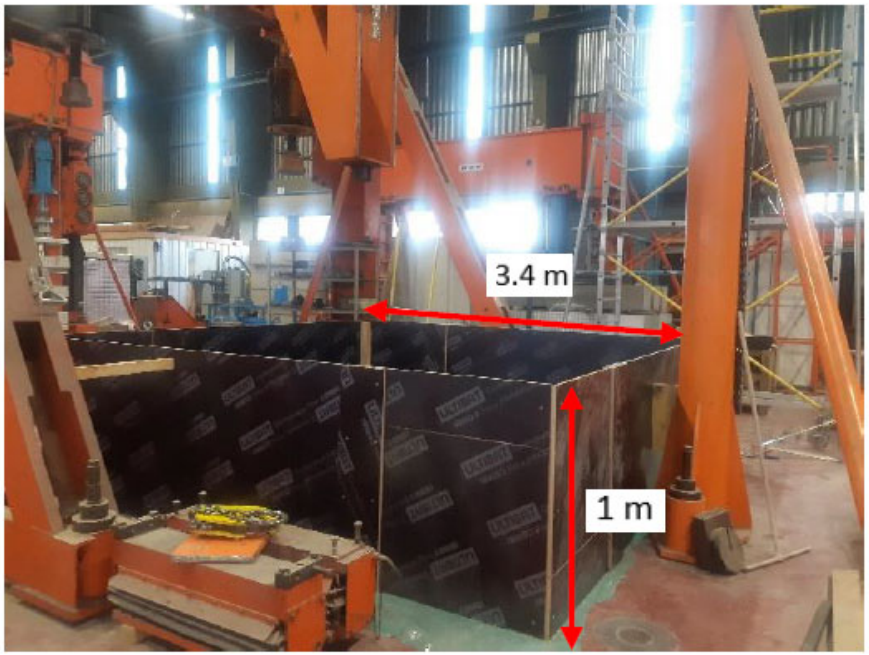
3- Instrumentation d’un modèle réduit

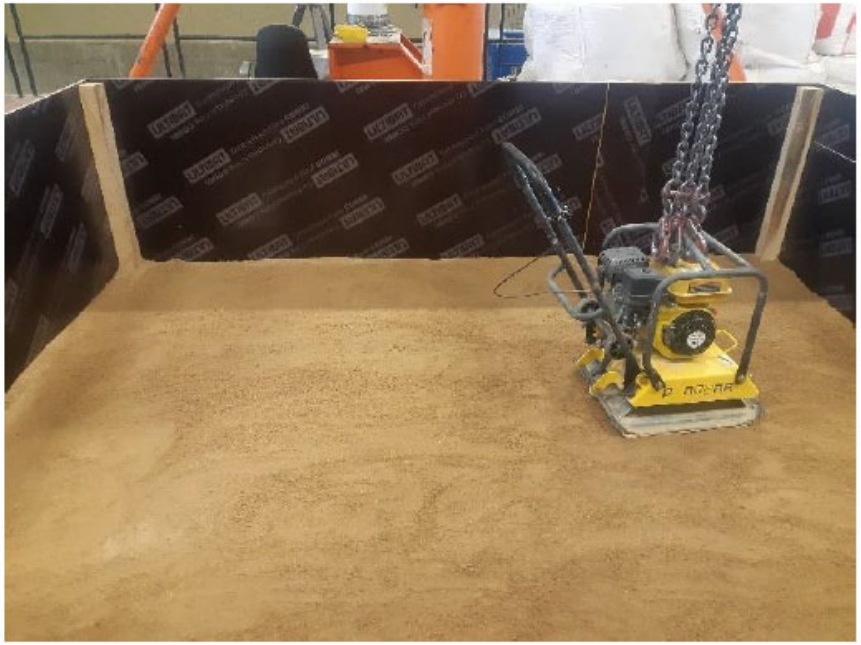
Construction



3- Instrumentation d’un modèle réduit

Construction

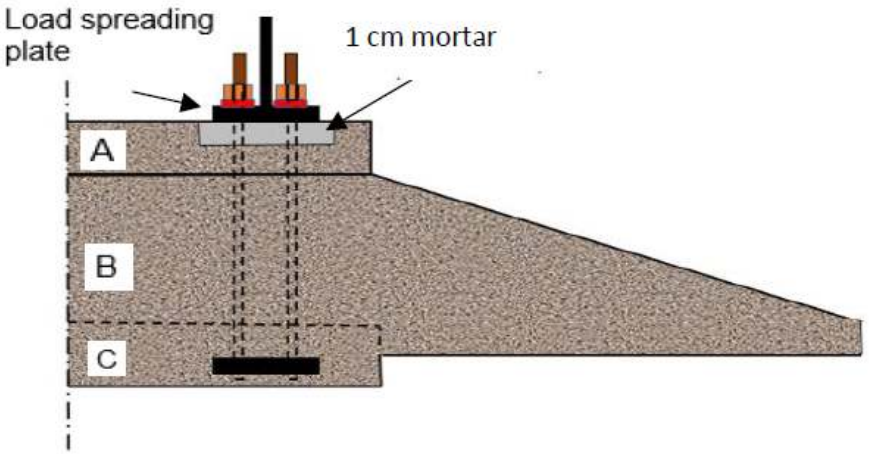




3- Instrumentation d’un modèle réduit

Construction



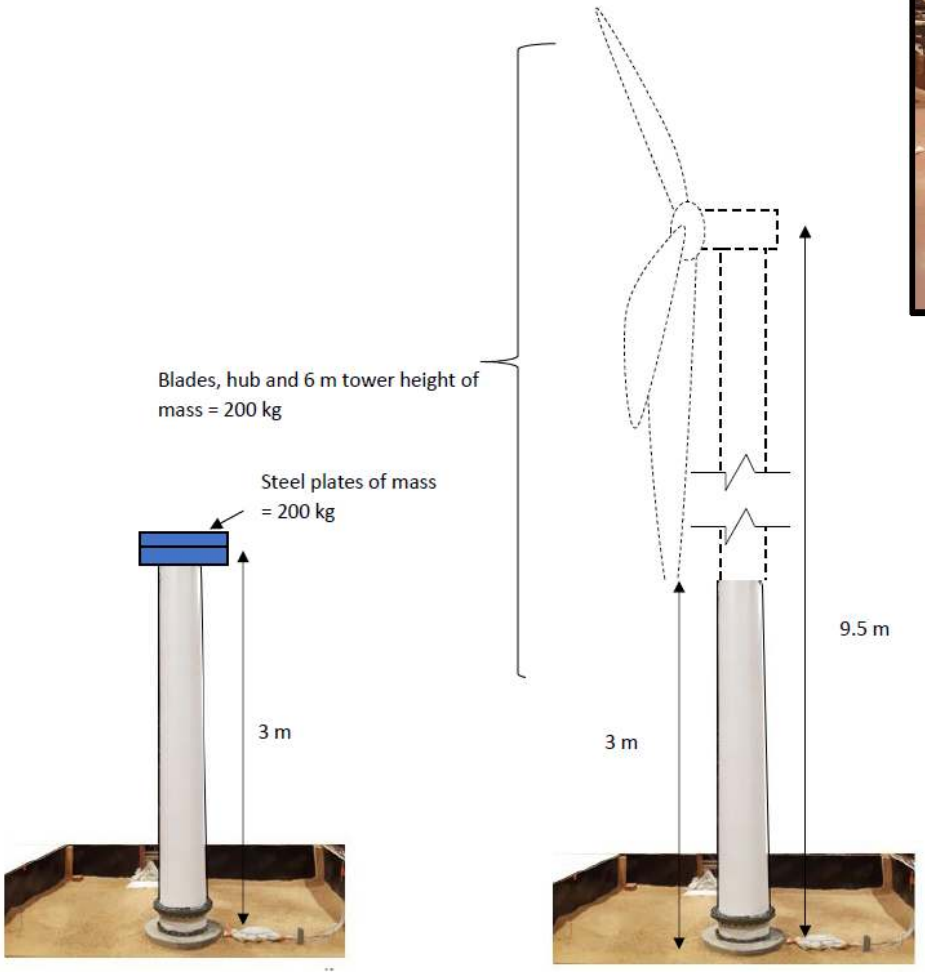






3- Instrumentation d’un modèle réduit

Construction

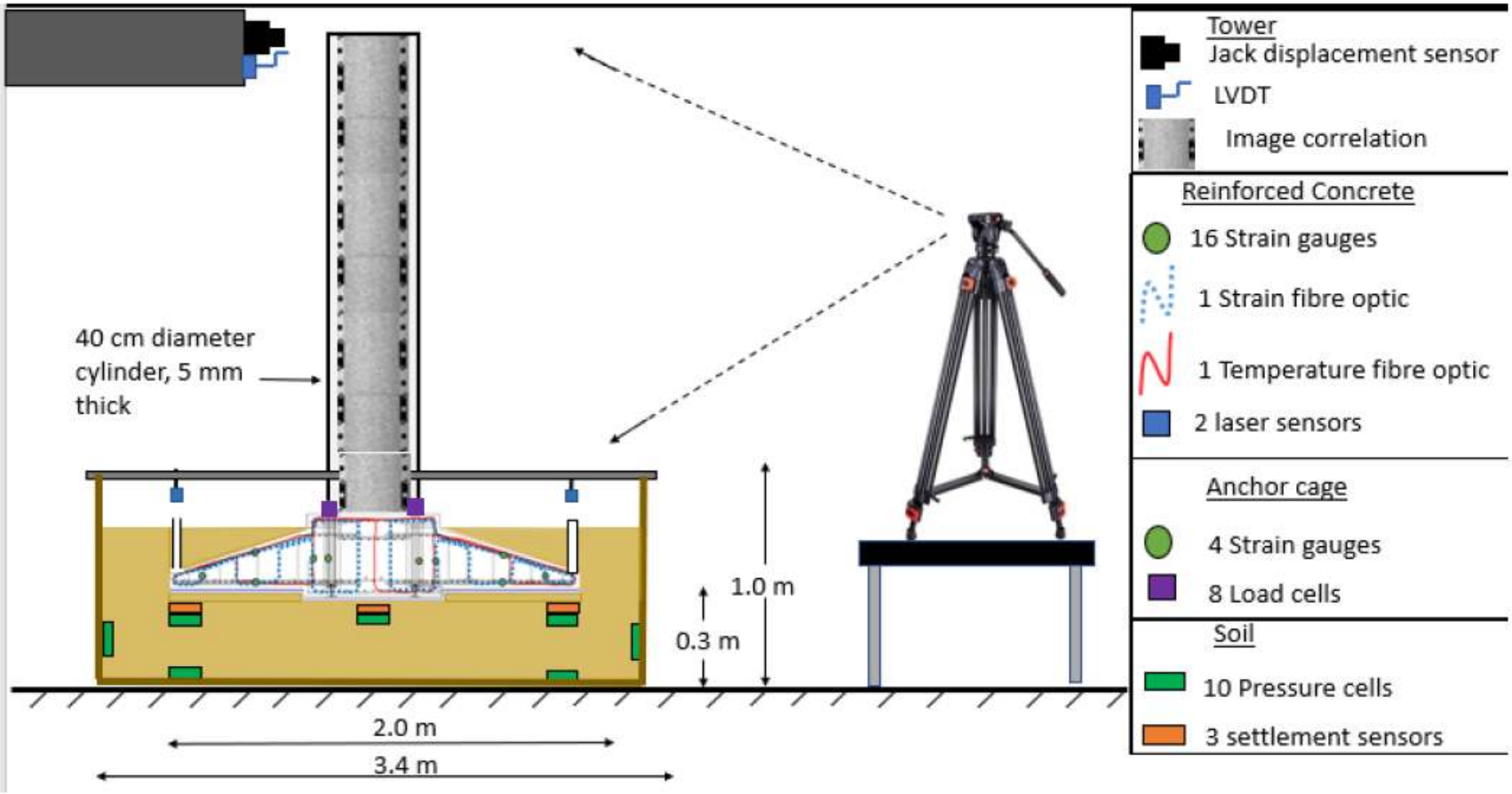






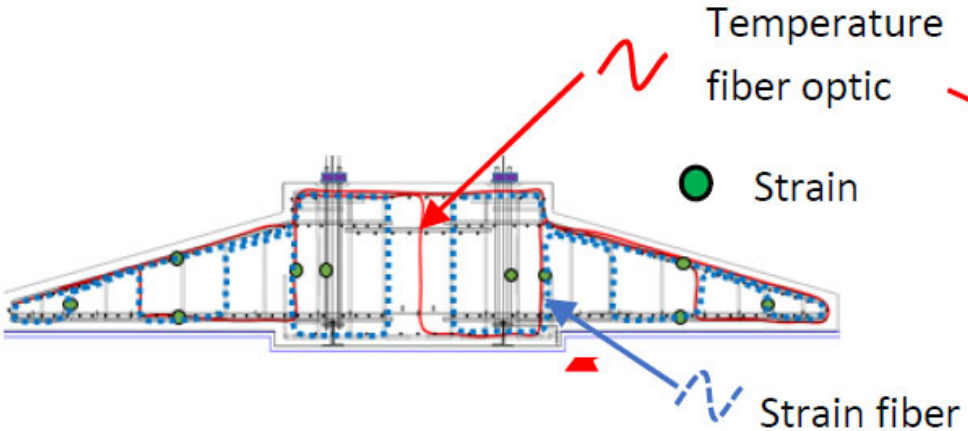
3- Instrumentation d'un modèle réduit

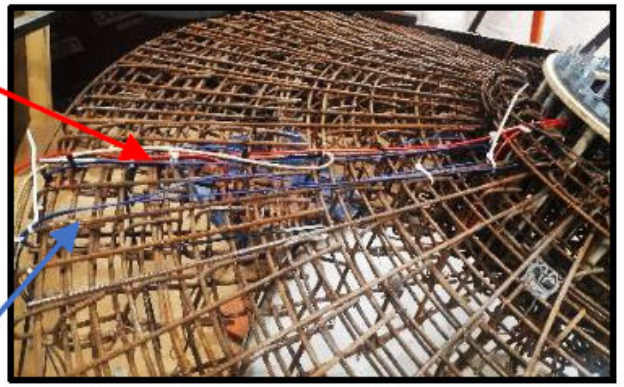
Instrumentation : synoptique

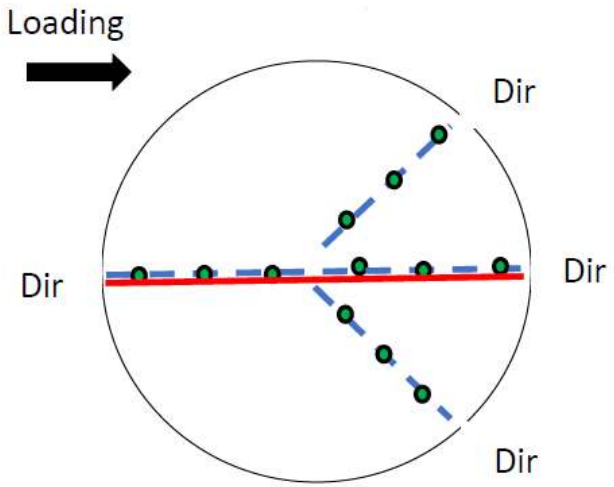


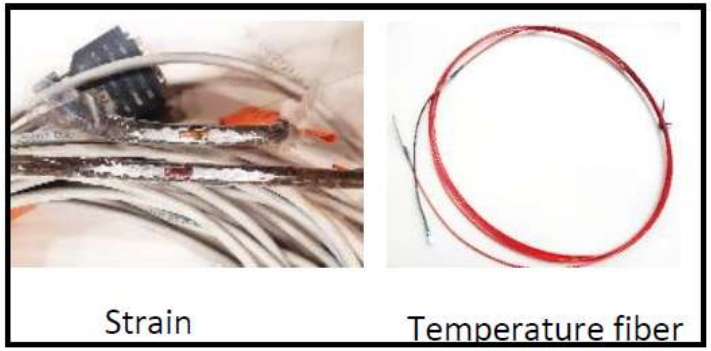
3- Instrumentation d'un modèle réduit

Instrumentation : jeune âge



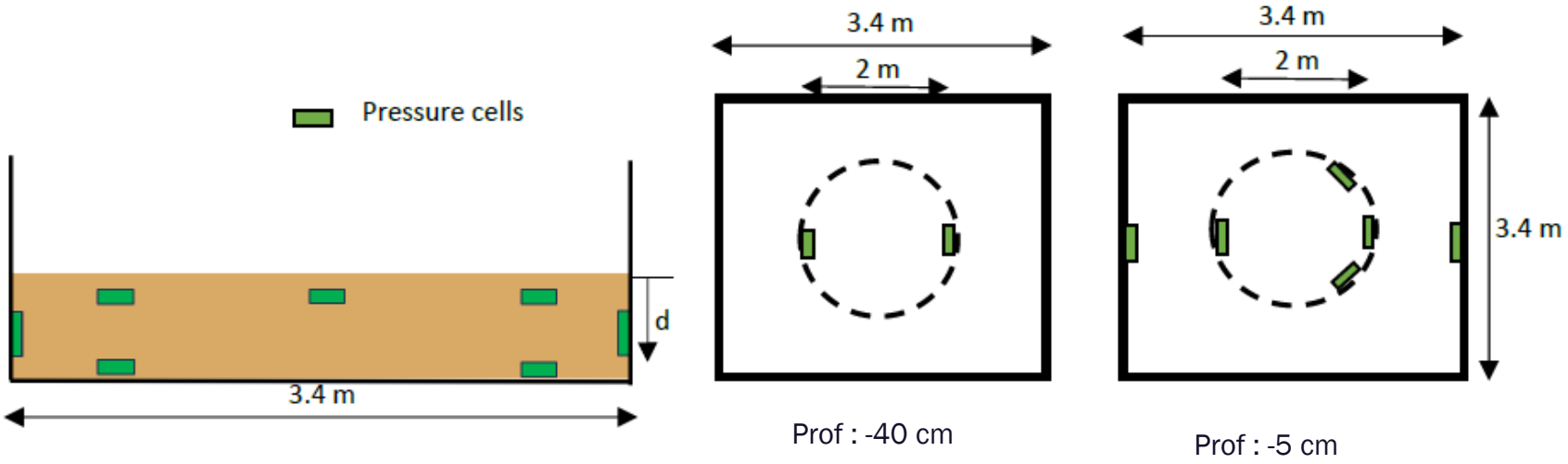


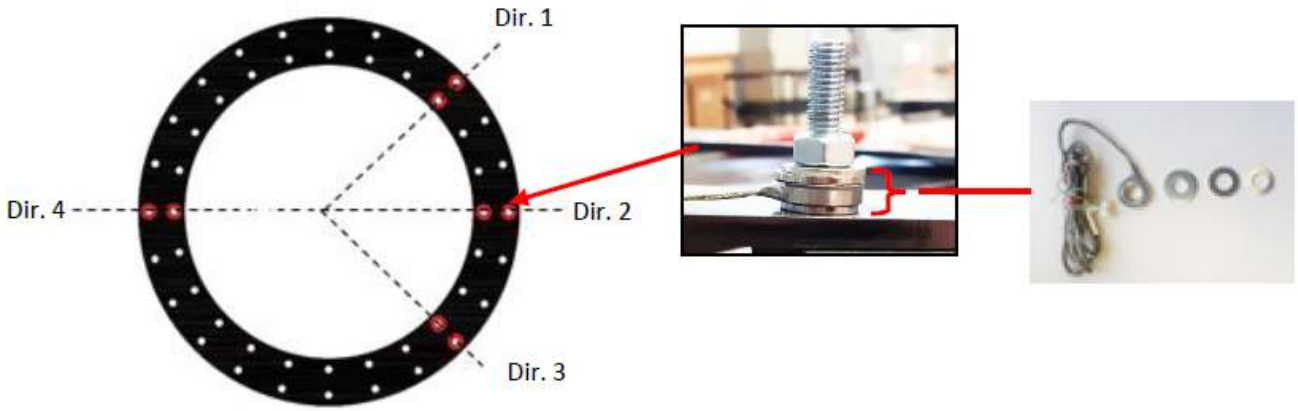




3- Instrumentation d'un modèle réduit

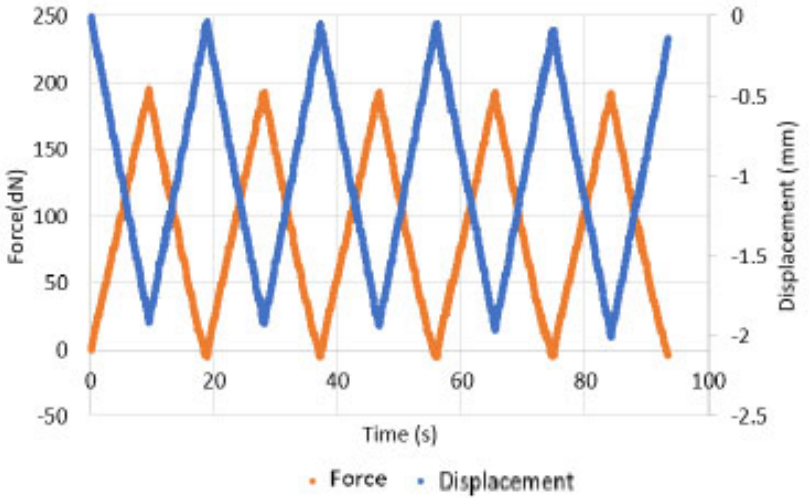
Instrumentation : pression / charge

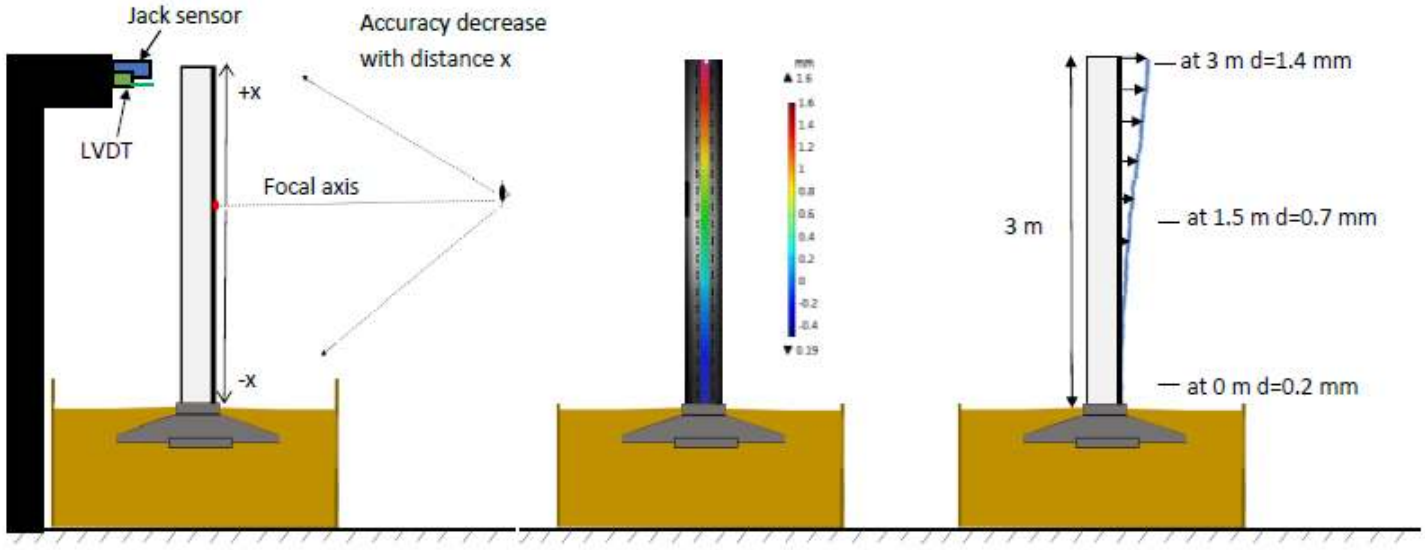




3- Instrumentation d’un modèle réduit

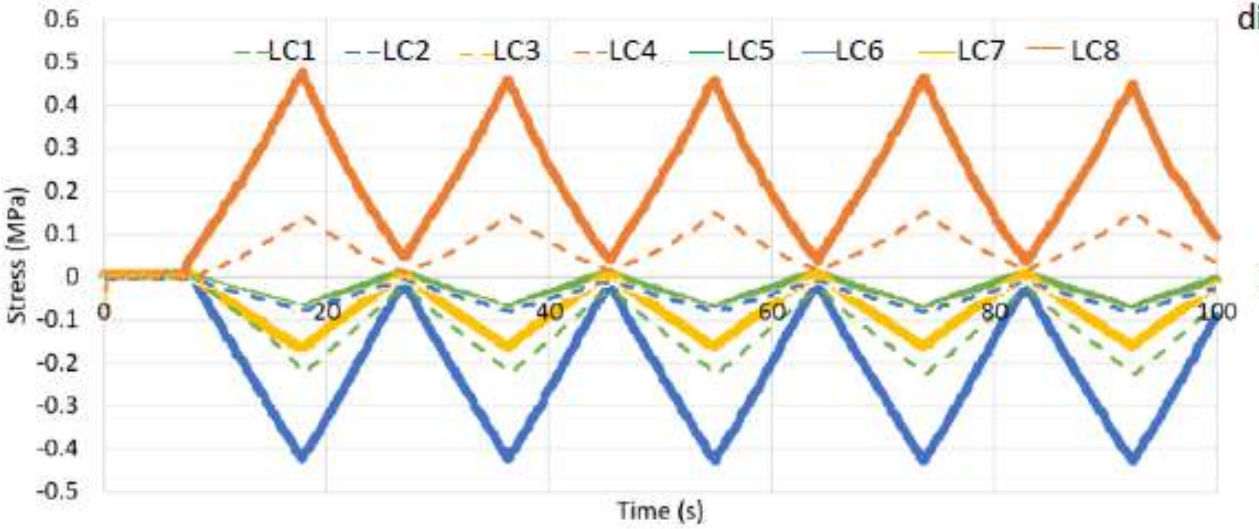
Mesures : application d’un effort cyclique

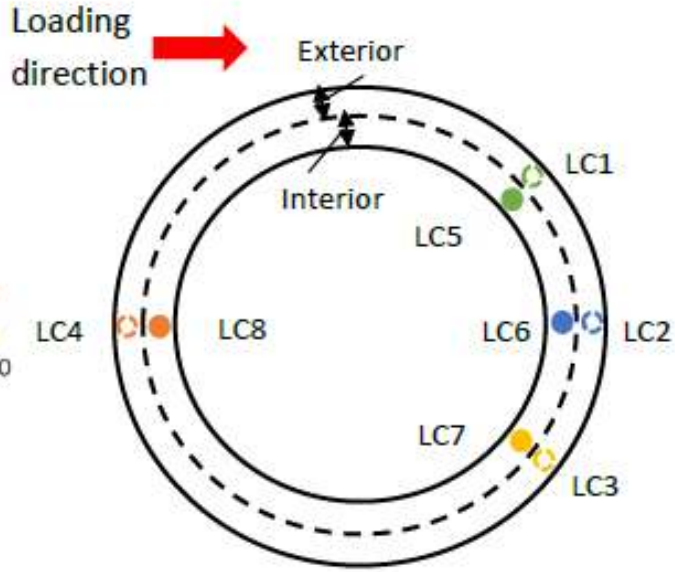




3- Instrumentation d’un modèle réduit

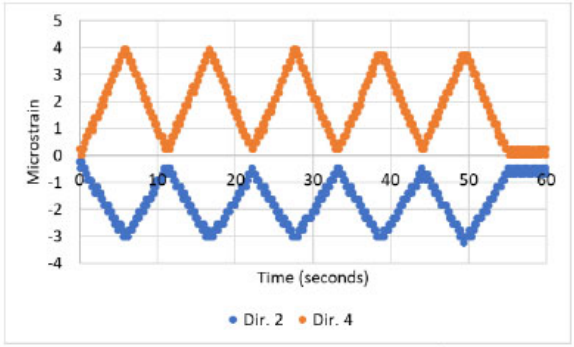
Mesures : effort cyclique -> contraintes dans les boulons

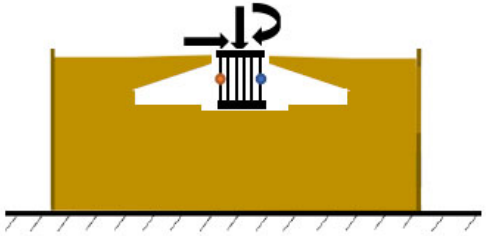


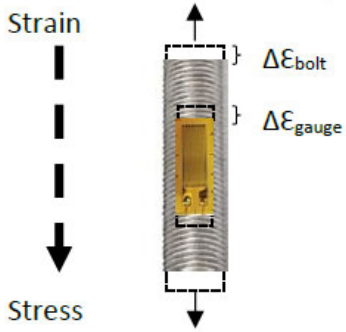


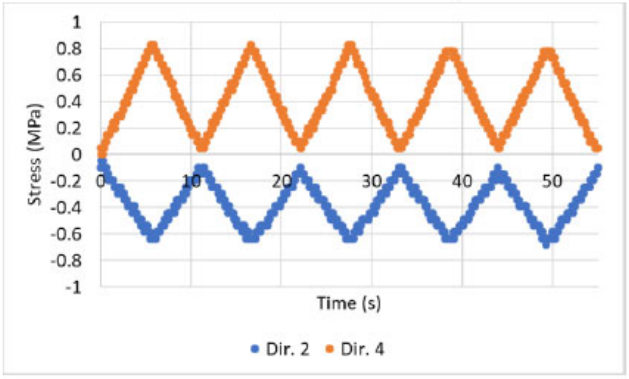
3- Instrumentation d'un modèle réduit

Mesures : effort cyclique -> déformation des ancrages







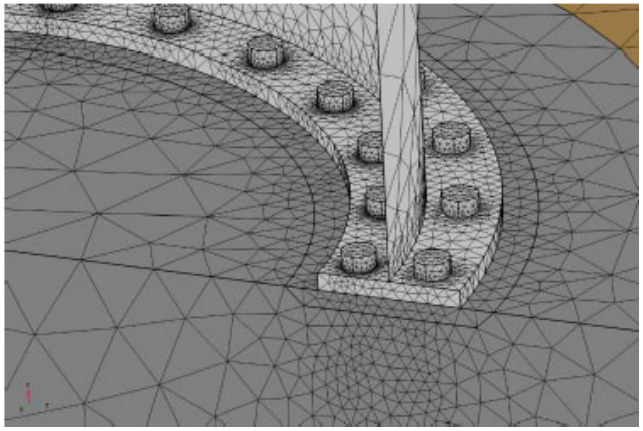


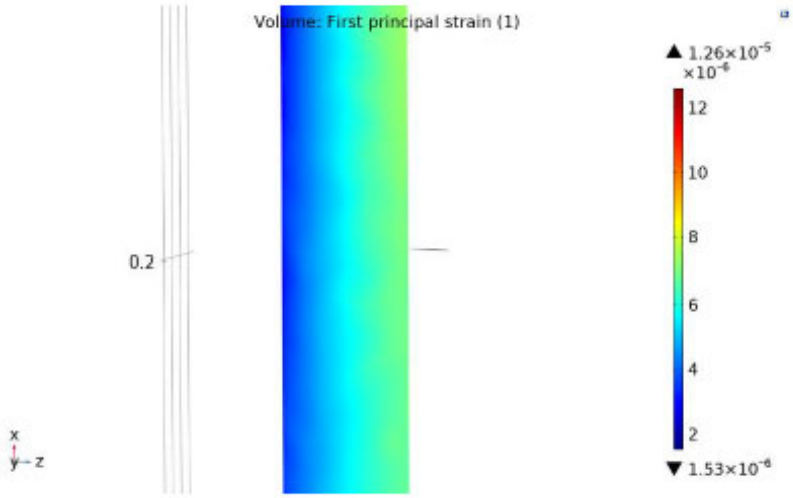
Assumption

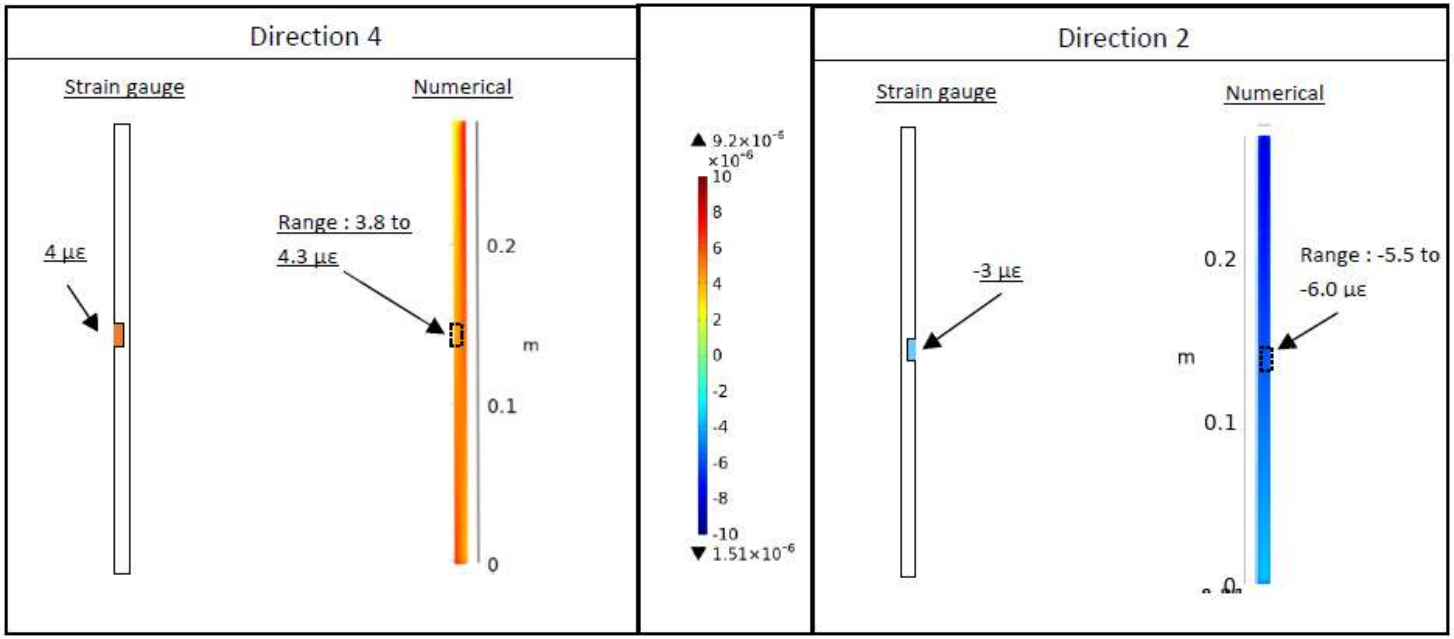
- $\Delta\varepsilon_{gauge}=\Delta\varepsilon_{bolt}$
- $E_{bolt}=210\ 00$ MPa

3- Instrumentation d'un modèle réduit

Mesures : effort cyclique -> charge des boulons

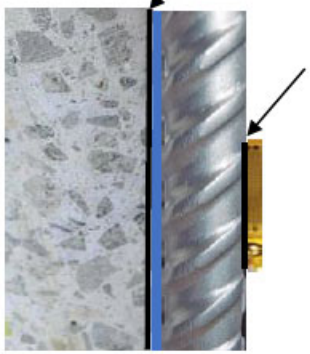


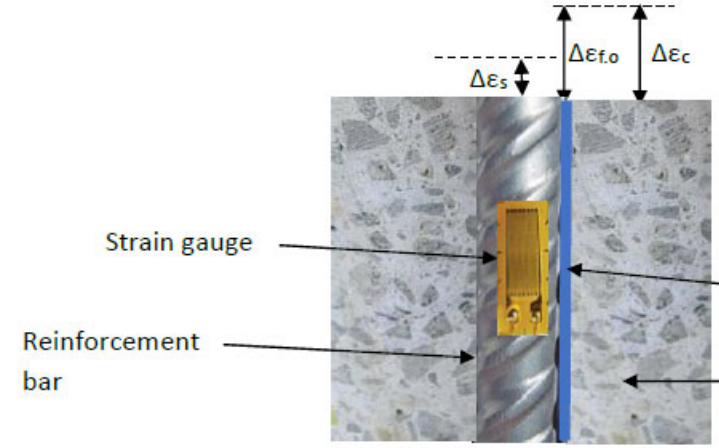




3- Instrumentation d'un modèle réduit

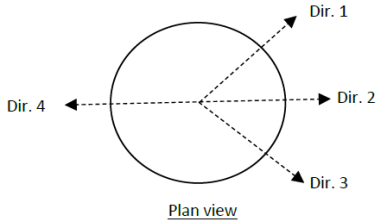
Mesures : effort cyclique -> déformations dans le béton



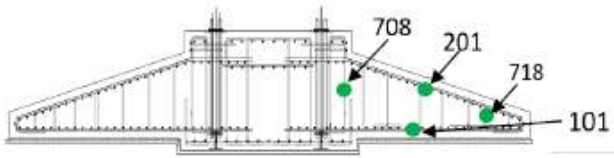


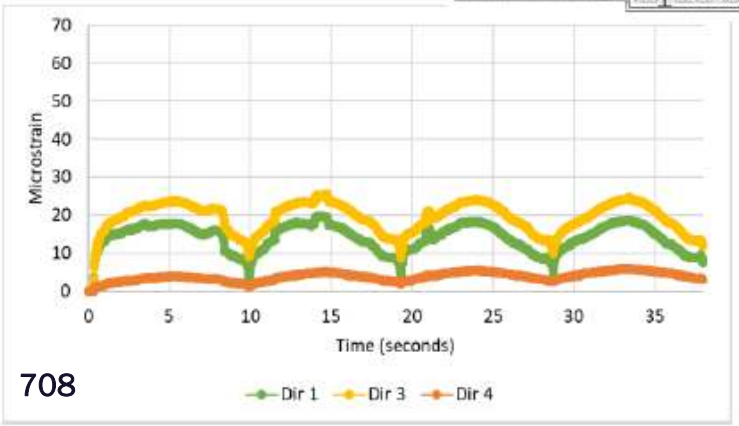
Assumption

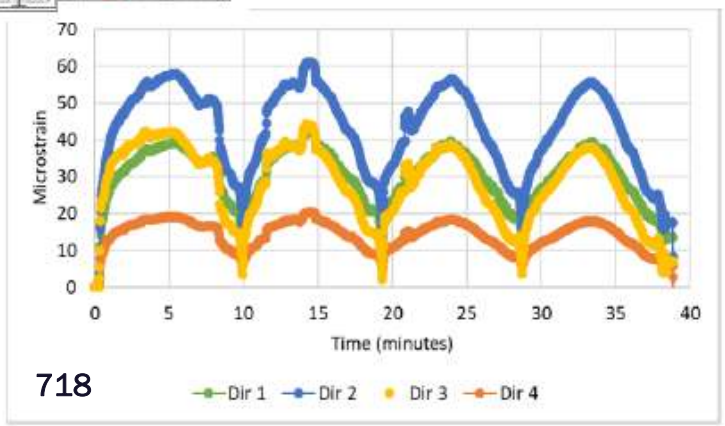
$\Delta\varepsilon_{f.o} \sim \Delta\varepsilon_c$



Plan view

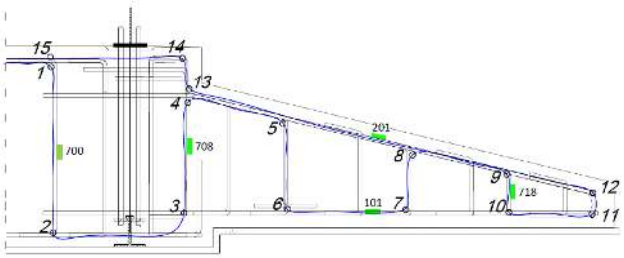


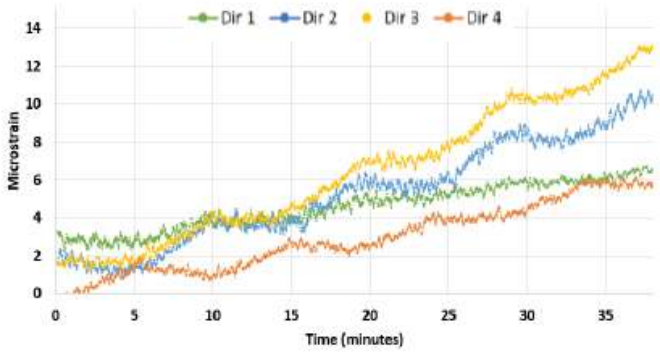




3- Instrumentation d'un modèle réduit

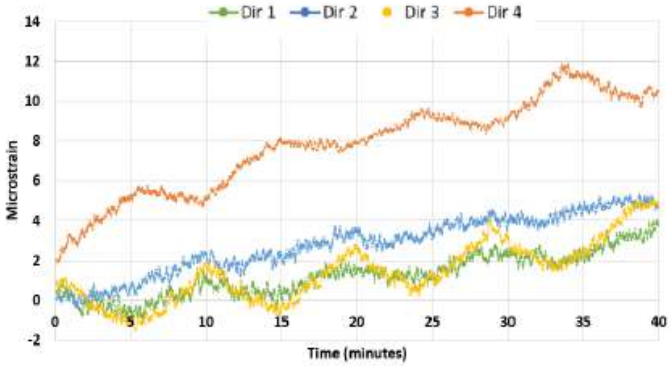
Mesures : effort cyclique -> déformations dans le béton





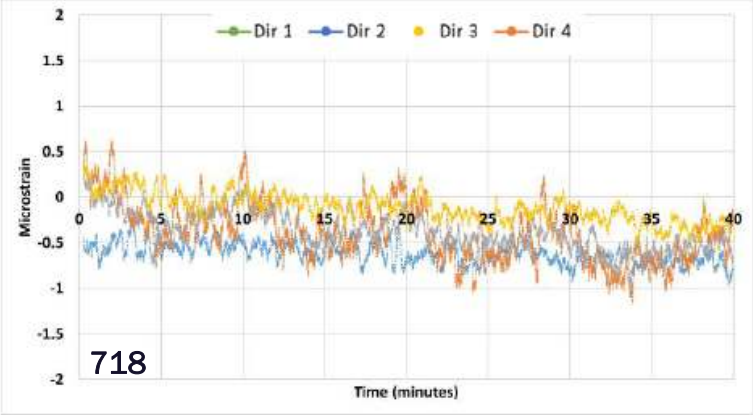
700

(a)

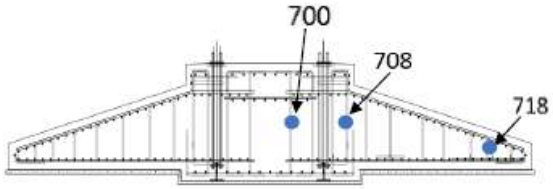


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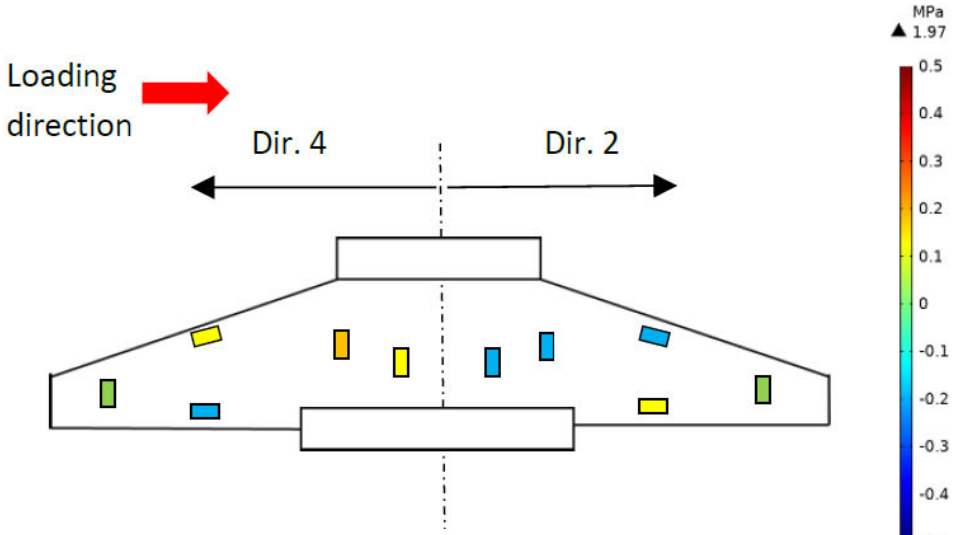


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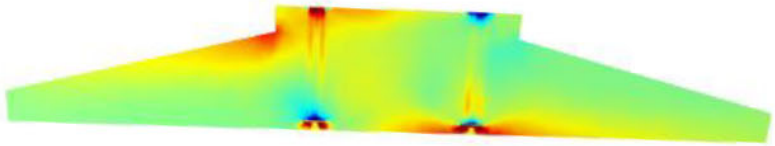


3- Instrumentation d’un modèle réduit

Mesures : effort cyclique -> déformations dans le béton



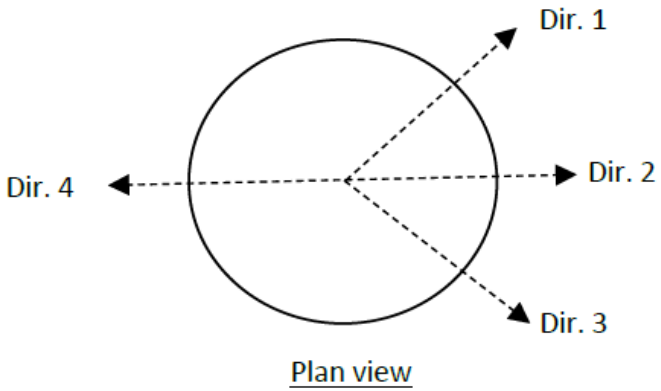
Mesures FO

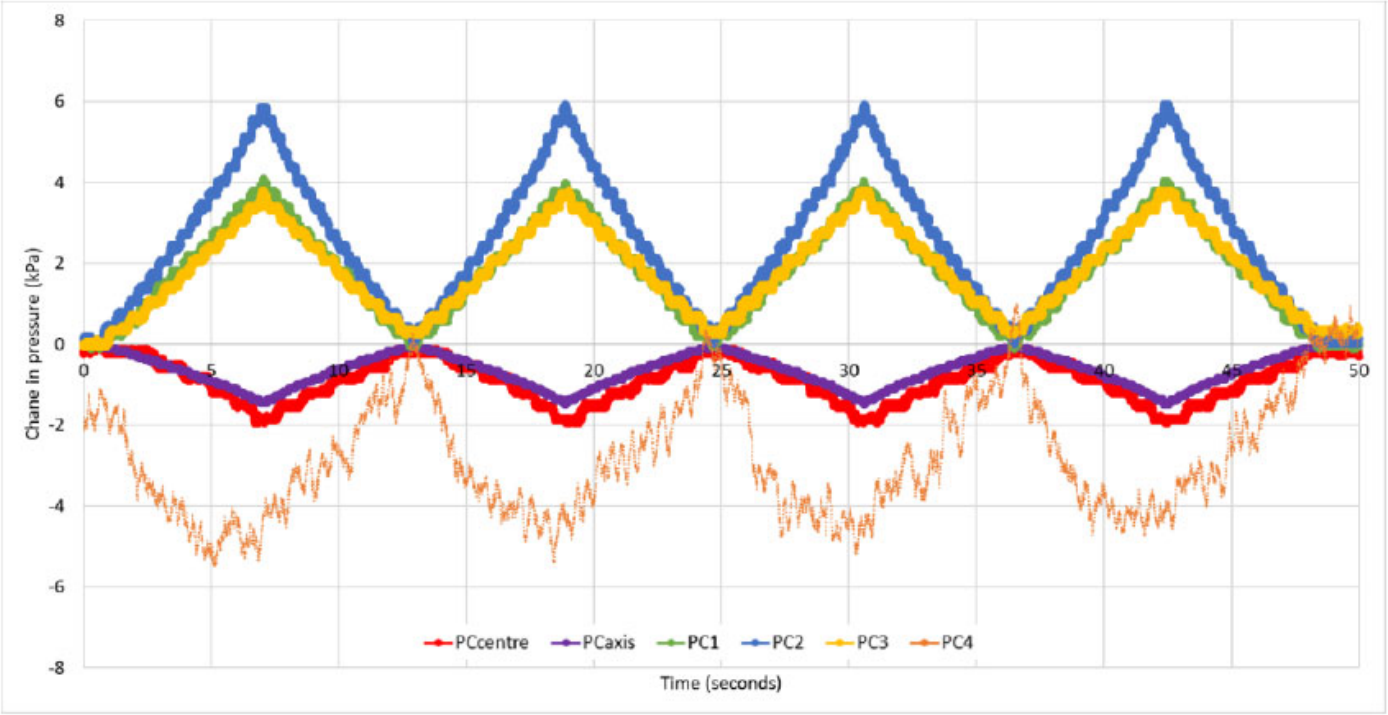


Simulation numérique

3- Instrumentation d’un modèle réduit

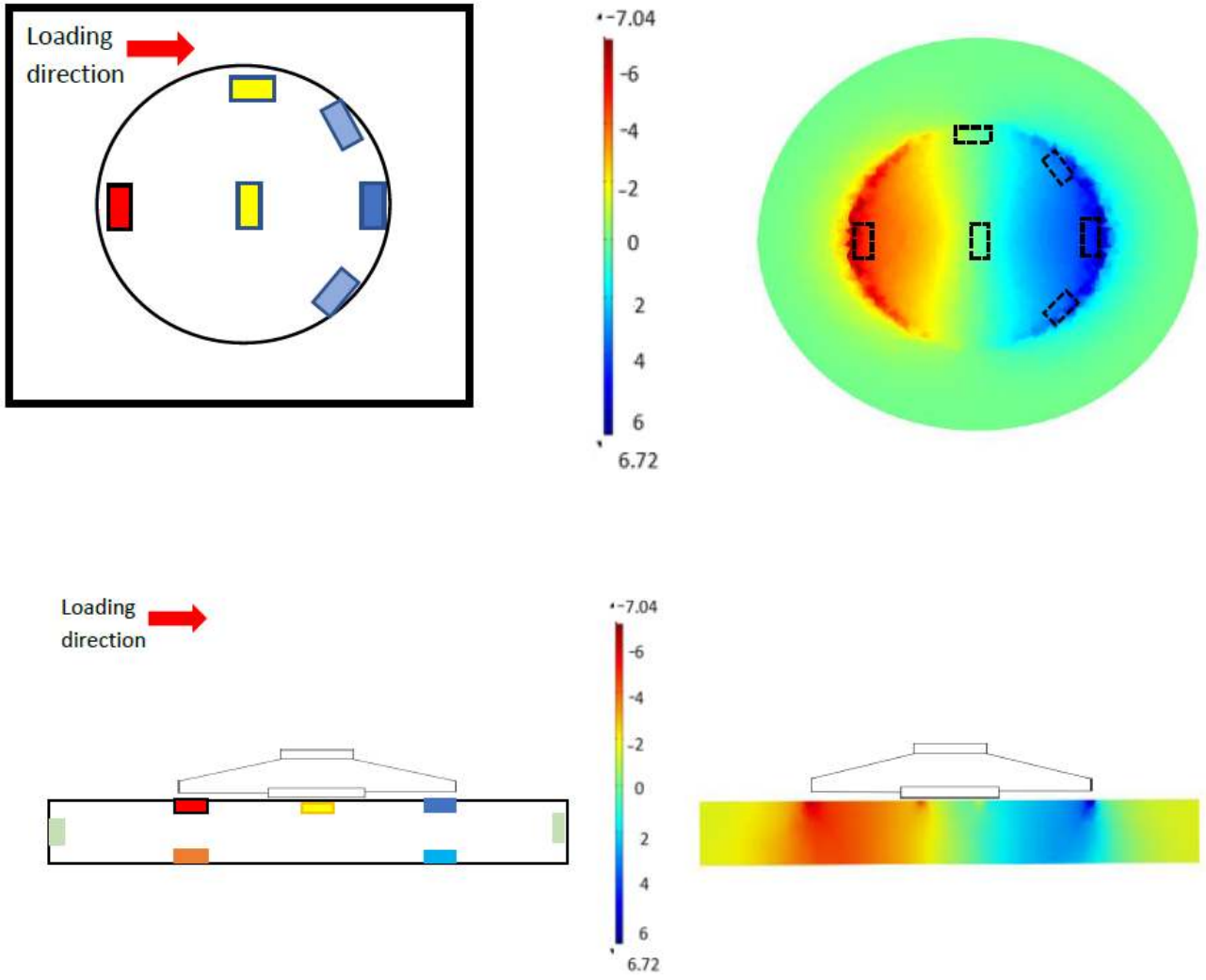
Mesures : effort cyclique -> contraintes dans le sol





3- Instrumentation d'un modèle réduit

Mesures : effort cyclique -> contraintes dans le sol



4- Apprentissages

- L'instrumentation poussée du modèle 1/10ème d'une fondation d'éolienne classique a permis de caler et valider le modèle numérique du modèle réduit ;
- Quelques points se sont avérés moins pertinents, notamment les jauges de déformation, comparativement à la F.O. ;
- La démarche a validé l'intérêt de la construction d'une seconde maquette au 1/10ème, d'une éolienne avec repowering ;
- Les enseignements bénéficieront ensuite à un modèle numérique au 1/10ème et enfin à échelle réelle d'une solution de repowering. L'instrumentation d'une fondation réelle avec repowering serait alors une validation de grand intérêt.

