

SSHEAR
SOILS, STRUCTURES & HYDRAULICS
Expertise and Applied Research



Journée publique de restitution
Mercredi 11 Septembre 2019, Marne-la-Vallée

Modélisation physique des affouillements: expérimentations en canal hydraulique

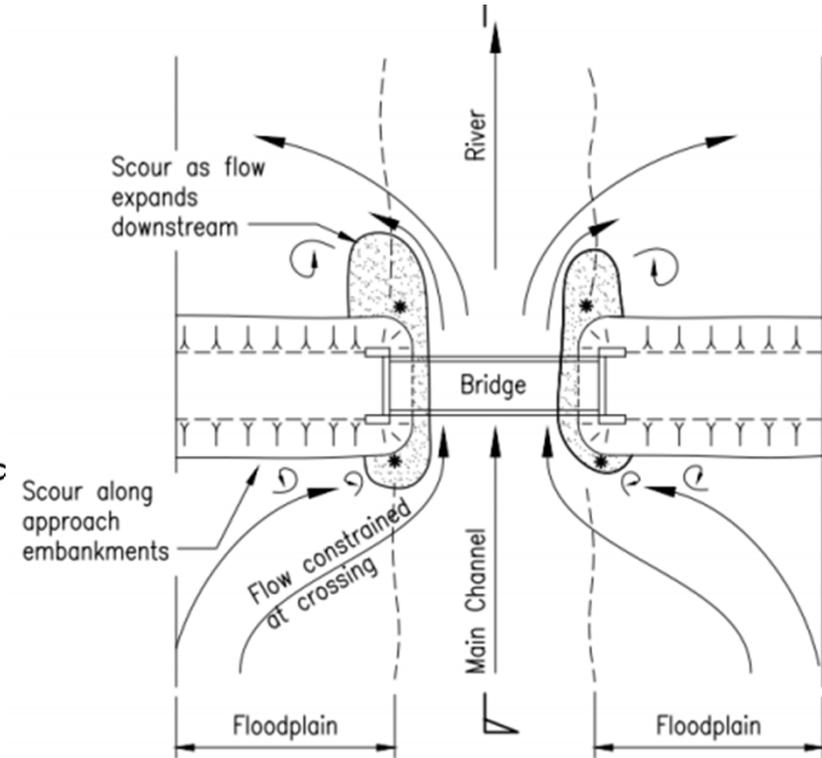
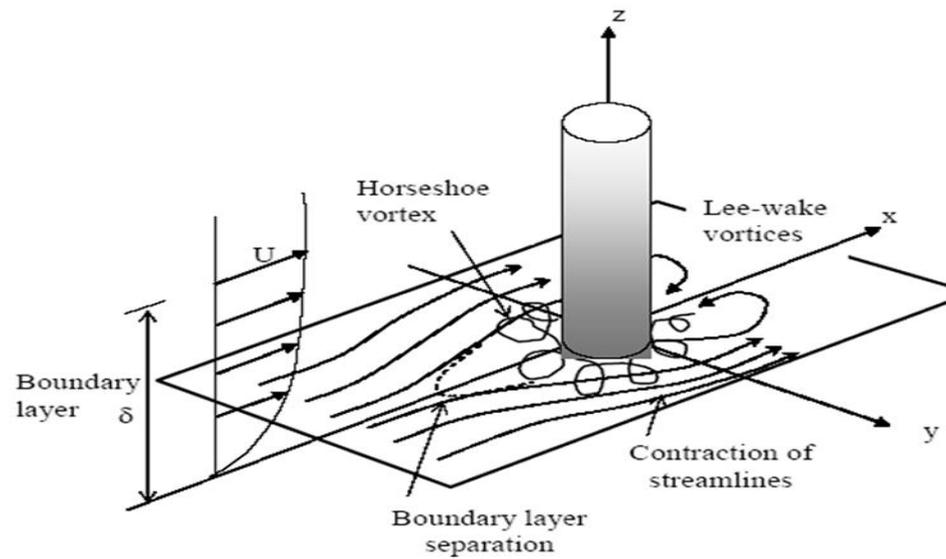
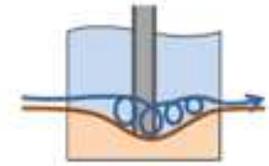
Damien Pham Van Bang, *Cerema-LHSV, INRS*

Frédérique Larrarte, Franziska Schmidt, Christophe Chevalier, *Ifsttar*

Pierre-Louis Gibelin, Vincent Vidal, *Cerema-LHSV*



Etude en canal sur un ouvrage modèle



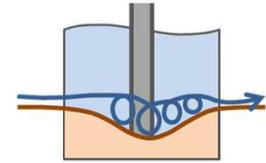
- Etude sur une pile isolée

- Processus physiques
- Vortex ‘fer à cheval’
- Sillage
- Sour depth sensor

- Etude sur ouvrage modèle

- Effets *multi-piles* cumulés
- Géométrie des fondations
- Tablier (appui simple ou encastrement)
- Analyse vibratoire sur l’ouvrage

Plan de l'exposé



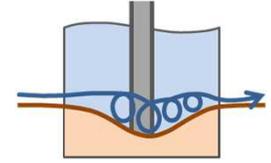
- 1. Conception et développement

- Montage
- Bathymétrie
- Véllocimétrie



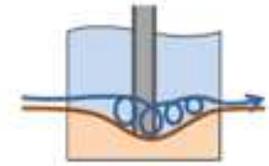
- 2. Résultats expérimentaux

- 1 pile ou tige isolée
- Analyse vibratoire
- Ouvrage modèle



1. Conception et Développement

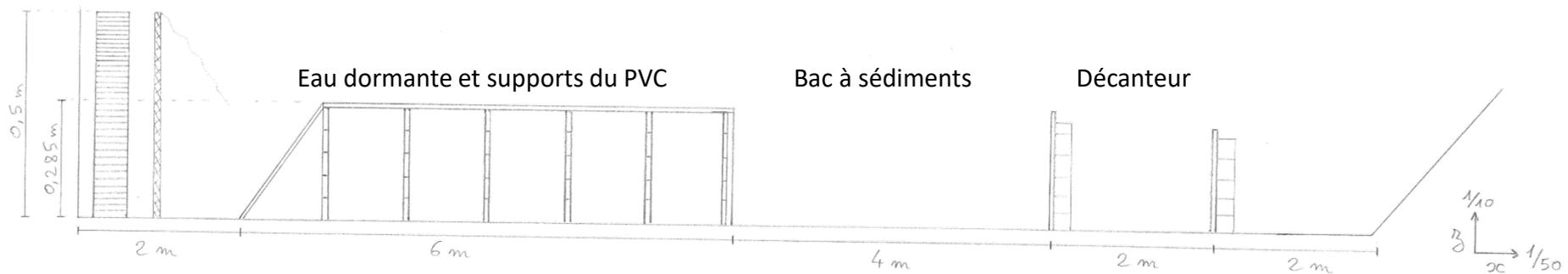
Partie 1. Conception et développement



- Canal 22 (F-78400 Chatou)
 - 16m x 2m x 0.5 m³
 - Pompe n°9: 150 L/s max
 - Niveau d'eau réglable par vanne
- Chariot mobile
 - Lit plat
 - support de capteur

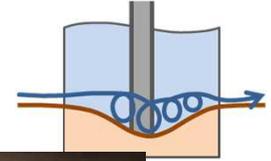


Nid d'abeilles

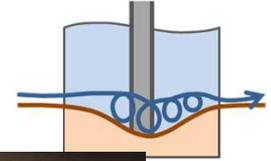


- Instrumentation

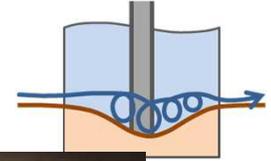
MSB : montage



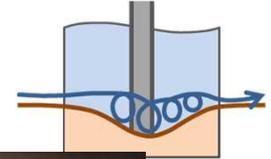
MSB : montage



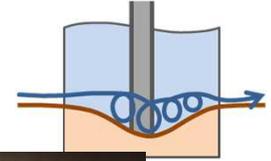
MSB : montage



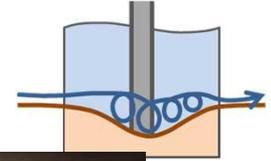
MSB : montage



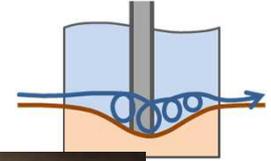
MSB : montage



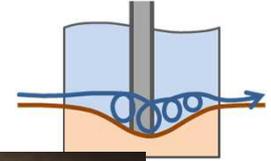
MSB : montage



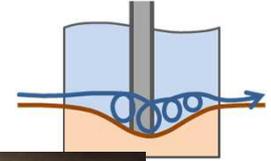
MSB : montage



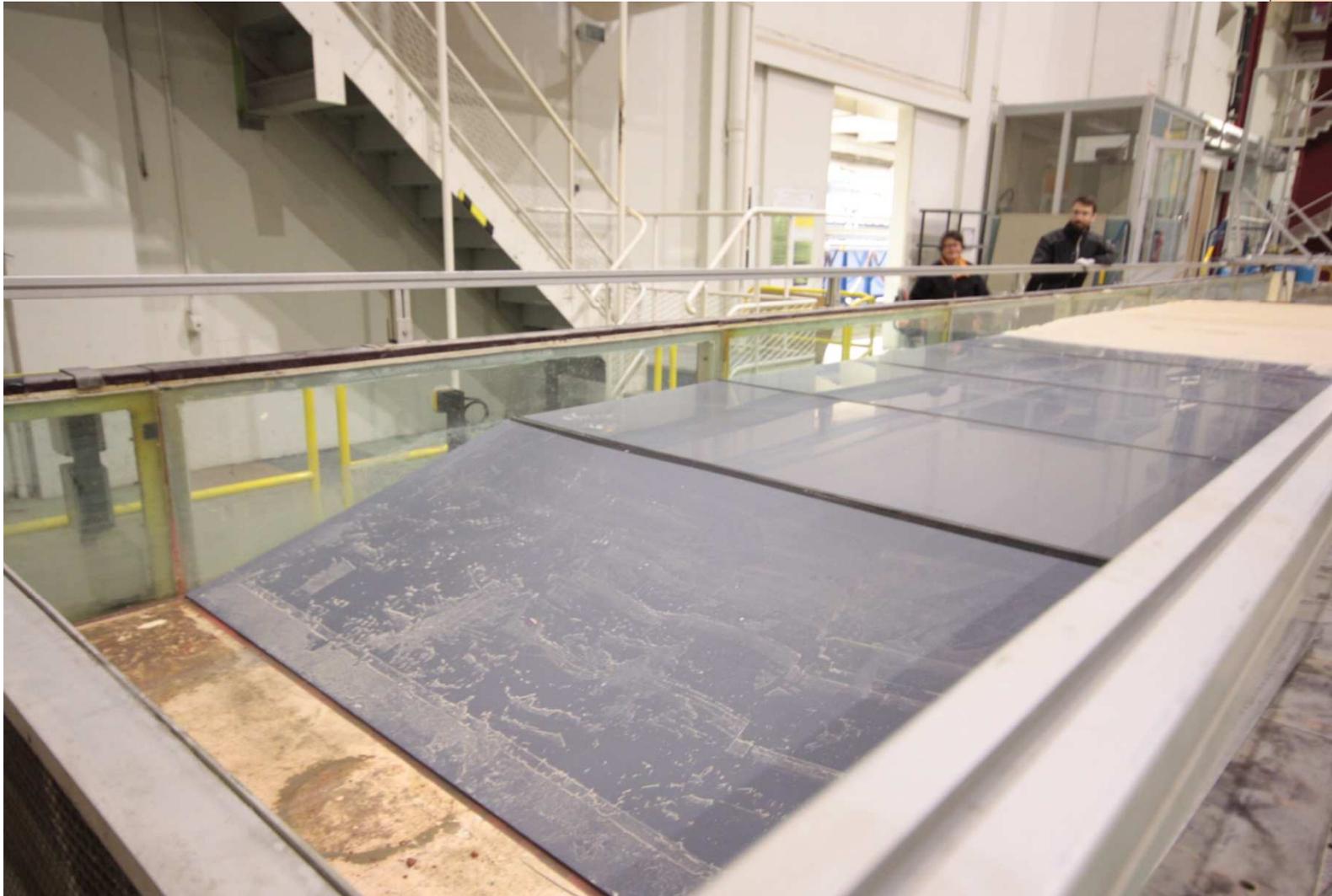
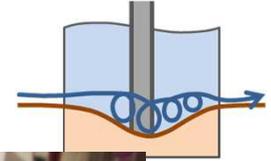
MSB : montage



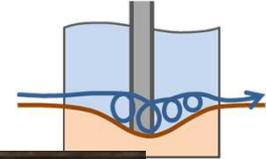
MSB : montage



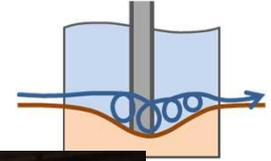
MSB : montage



MSB : Montage terminé



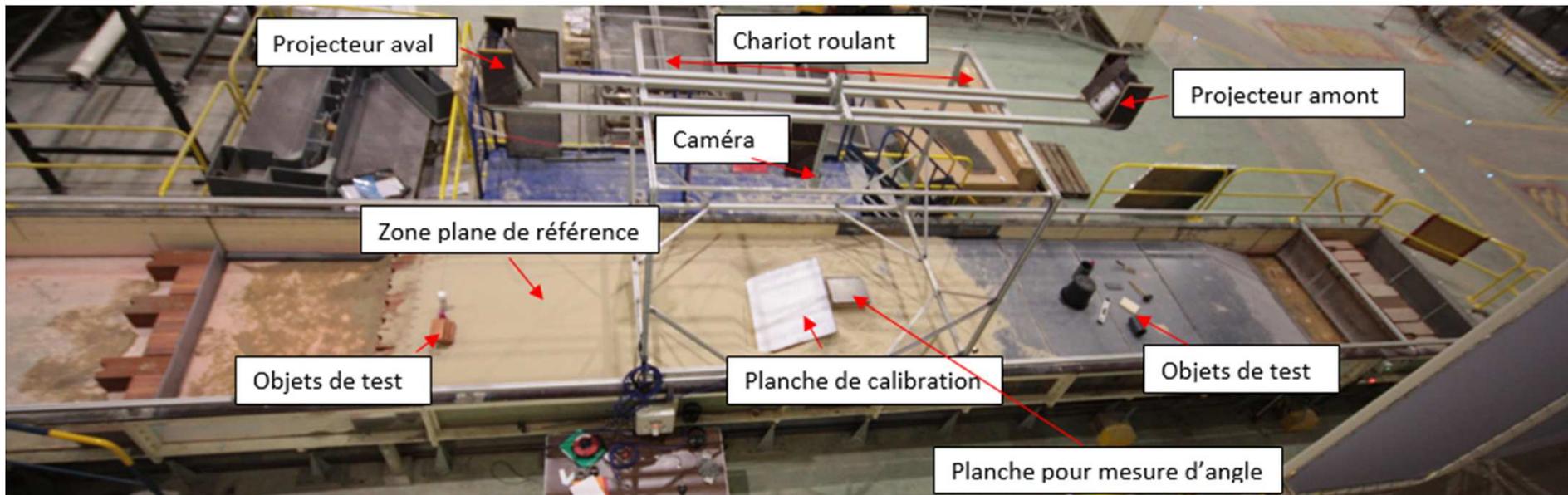
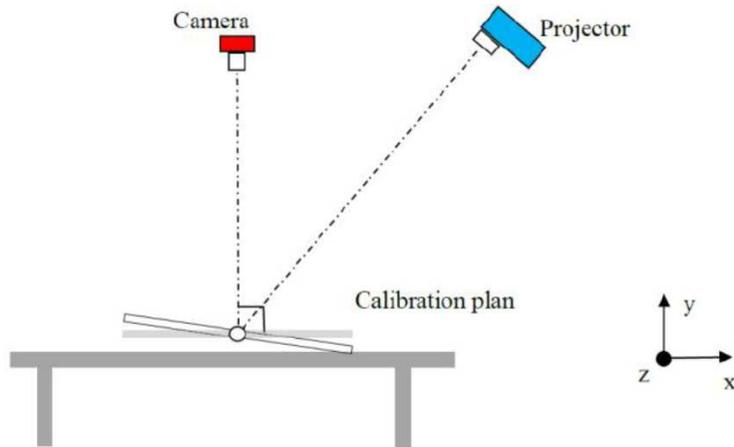
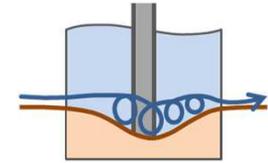
MSB : Validation



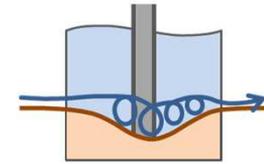
$h=10\text{cm}$
 $Q=30\text{L/s}$

Frontière Q-h entre '*clear water*' et '*lived bed scour*'

Instrumentation: Moiré d'ombres

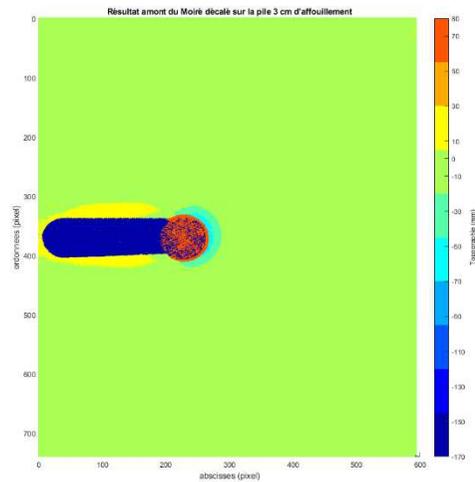
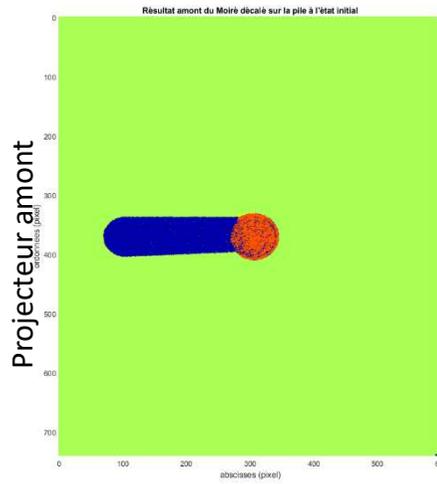


Instrumentation: Moiré d'ombres

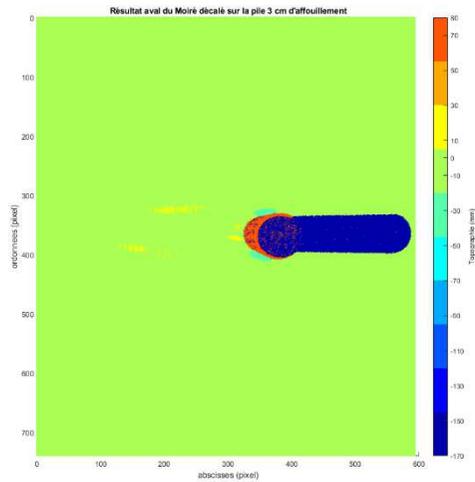
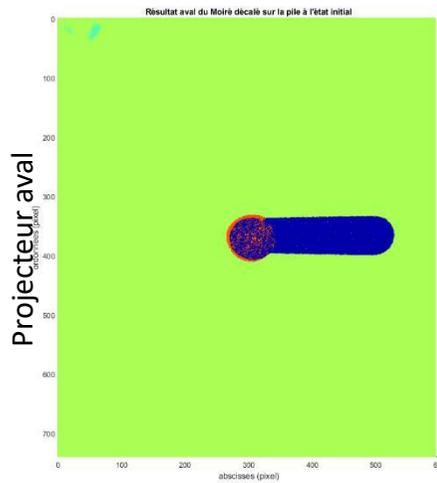
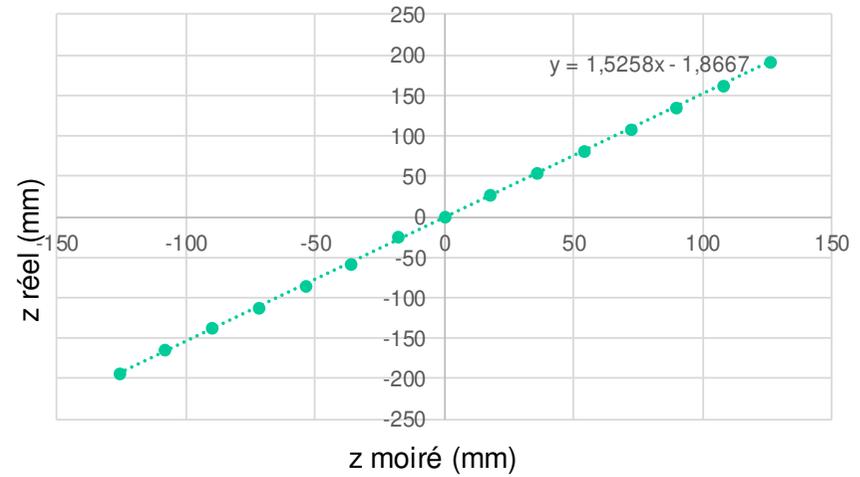


Etat initial

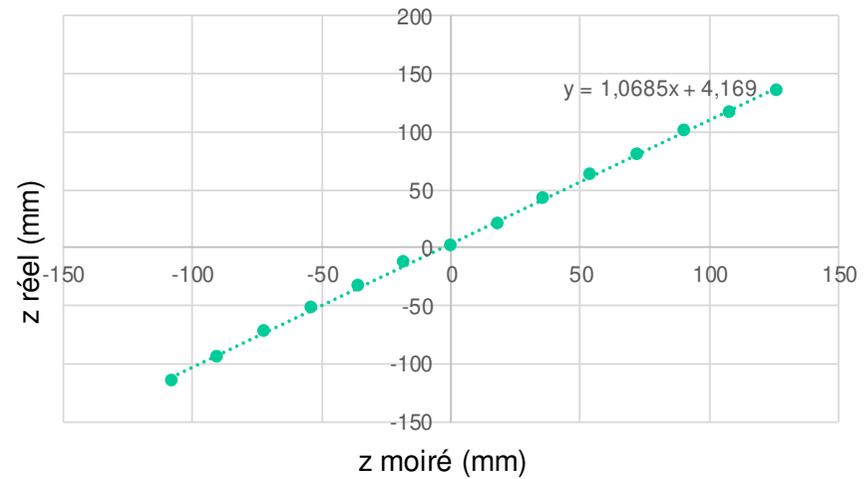
Affouillement 3 cm



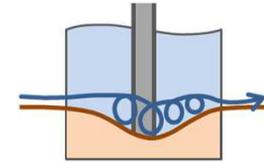
Fonction de correction amont



Fonction de correction aval

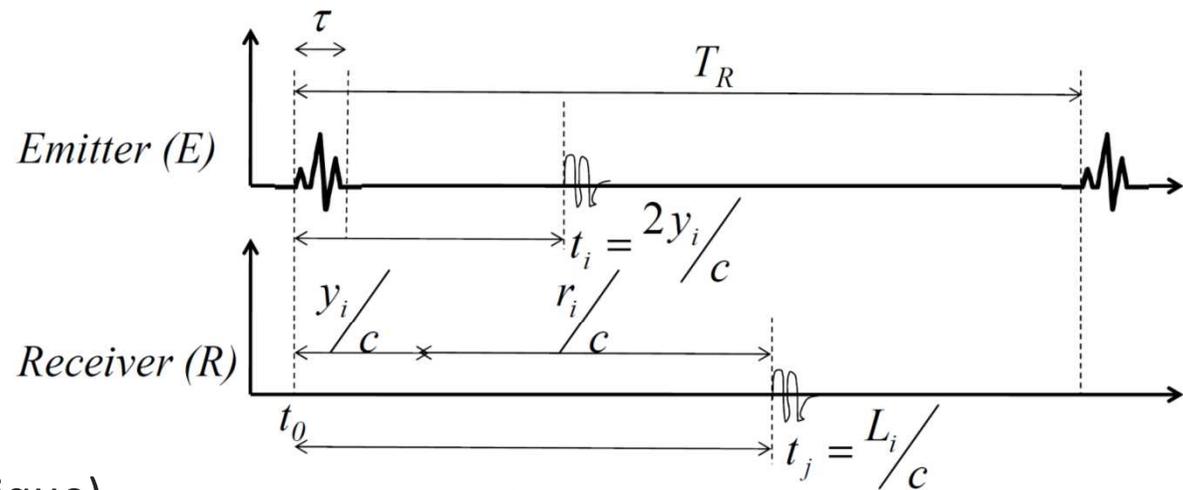


Instrumentation: Vélocimétrie acoustique



- **UB-Lab**

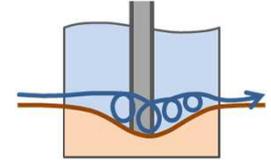
- Doppler pulsé
- Profil 1D et 2D (bi-statique)
- Bathymétrie ponctuelle (temps de vol)



τ : pulse length
 T_R : repetition period
 L_i : travel distance ($E - y_i - R$)



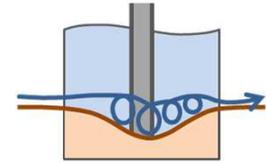
Profileur acoustique
avec son support



2. Résultats



2.1. Etude sur une pile

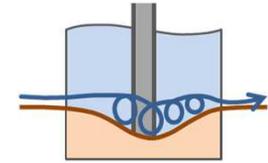


Hauteur d'eau
entre 8 et 17cm

Vitesse max (surface)
Entre 10 et 60cm/s



2.1. Etude sur une pile



Mono-pile instrumentée

- accéléromètre

- Sonde bathy-acoustique

Visualisation

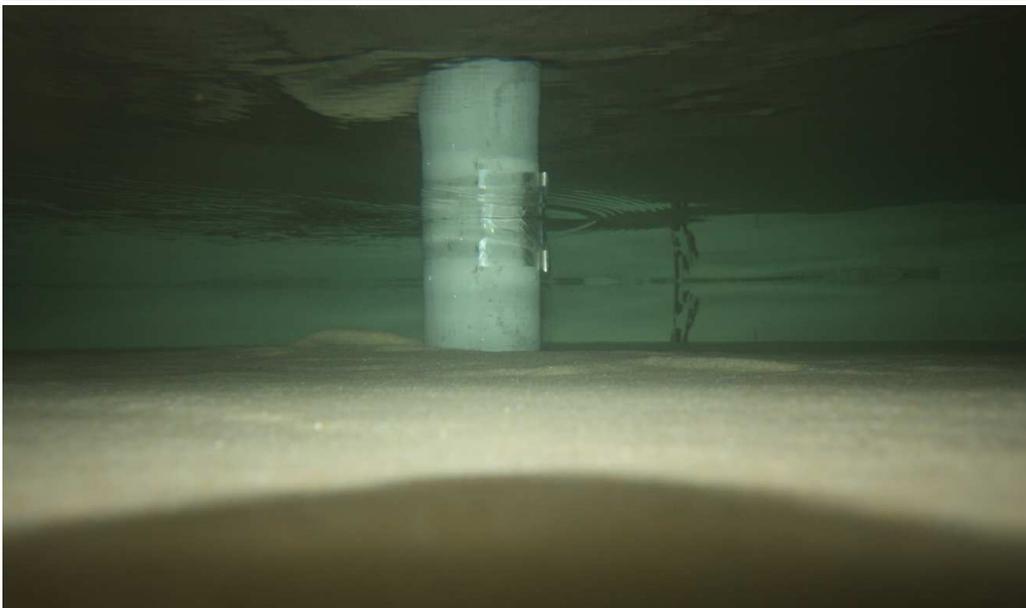
- Onde de surface de type
'bow wave'

- Sillage 'Lee wake vortices'

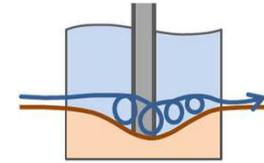
$$Re_D = Uh/\nu \sim 40000$$



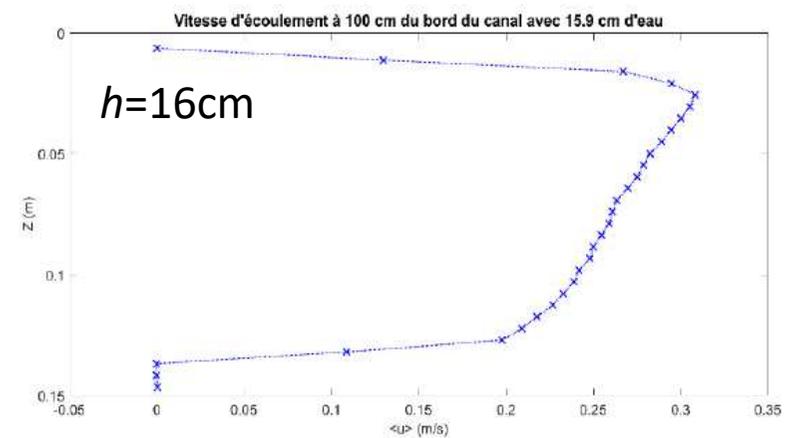
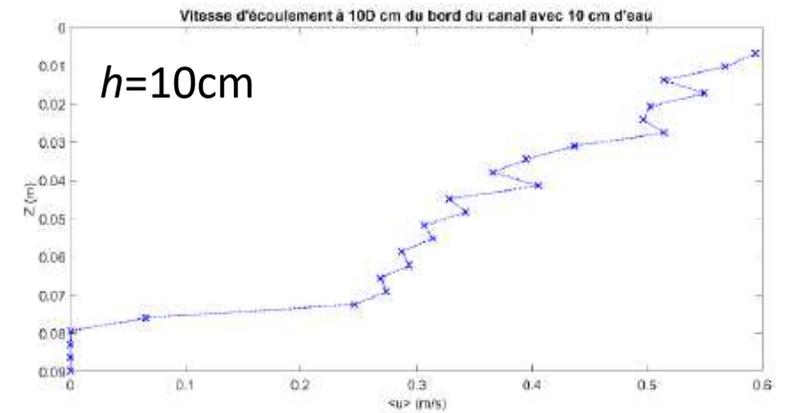
2.1. Etude sur une pile



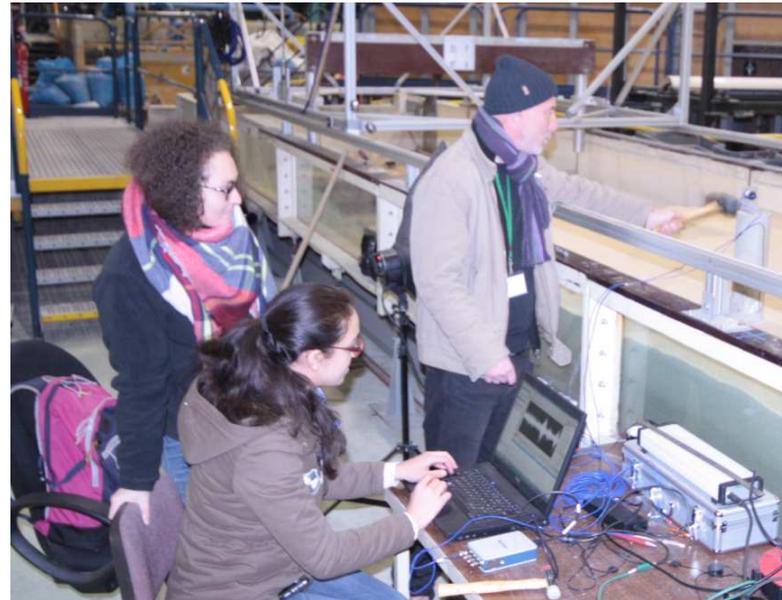
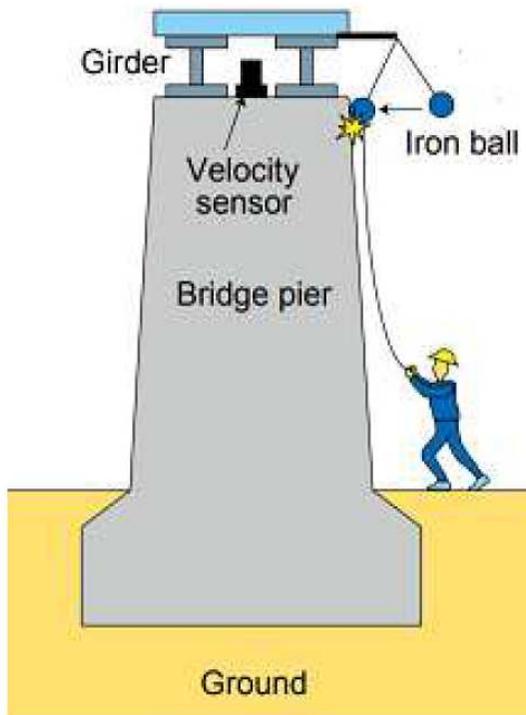
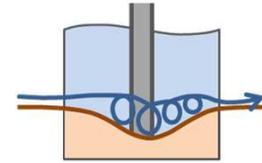
Hauteur d'eau
entre 8 et 17cm



Vitesse max (surface)
Entre 10 et 60cm/s

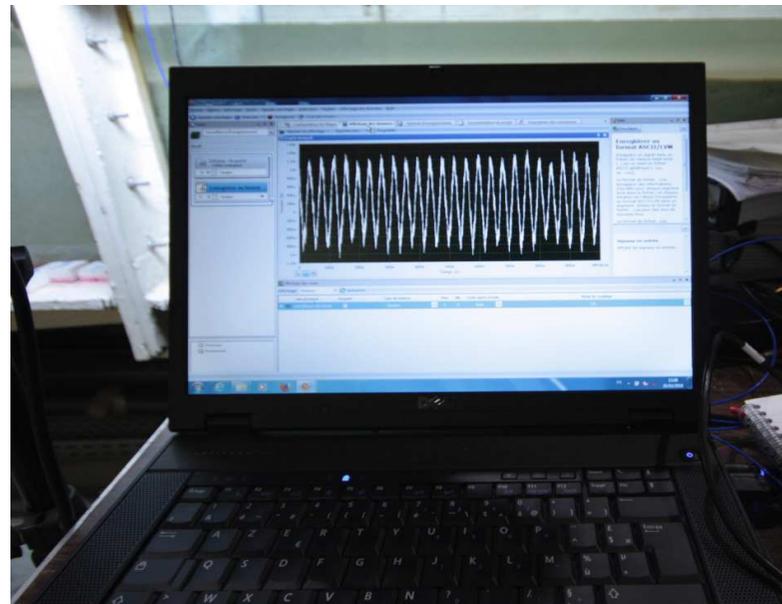


2.2. Vibration d'une tige et d'une pile



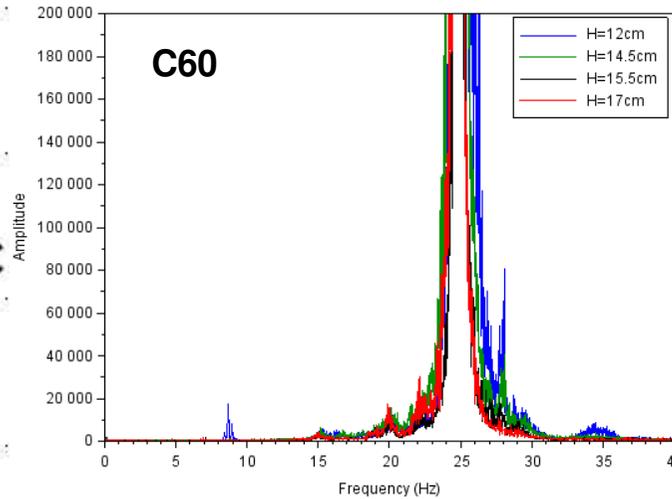
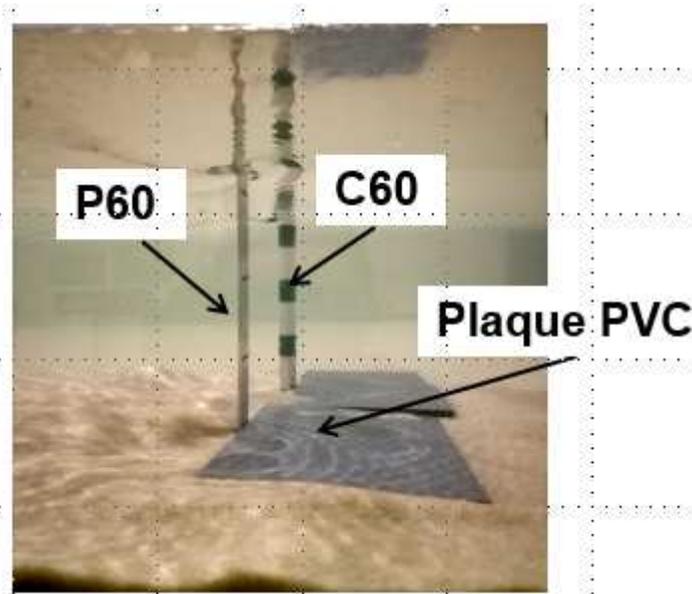
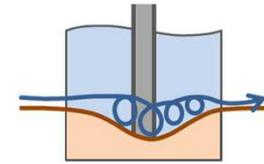
Equipe (tâche 3)

- Ifsttar
- Railenium
- Cerema

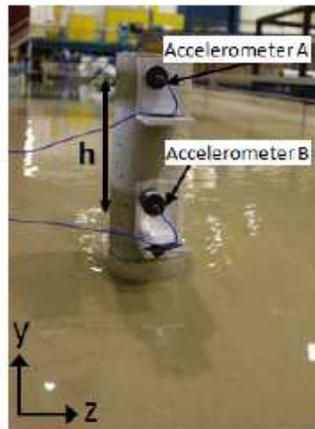


Analyse vibratoire

2.2. Vibration d'une tige et d'une pile



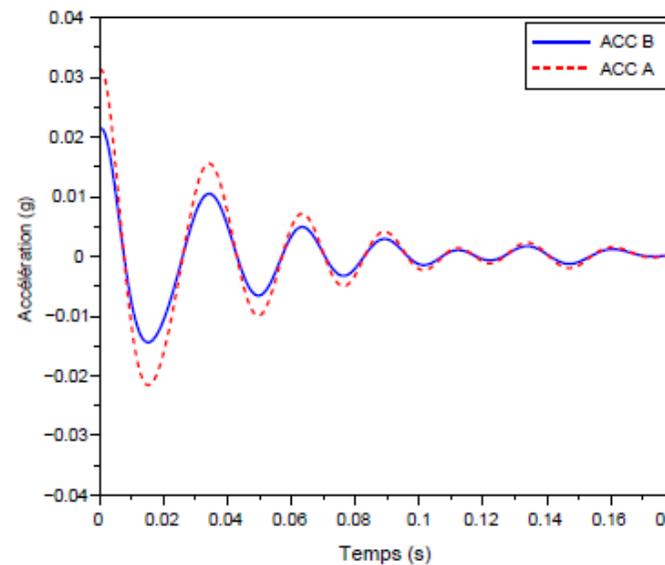
Scour depth sensor:
 - Variation de la fréquence de résonance avec la profondeur d'affouillement (Analogie *Cantilever*)



(a)



(c)



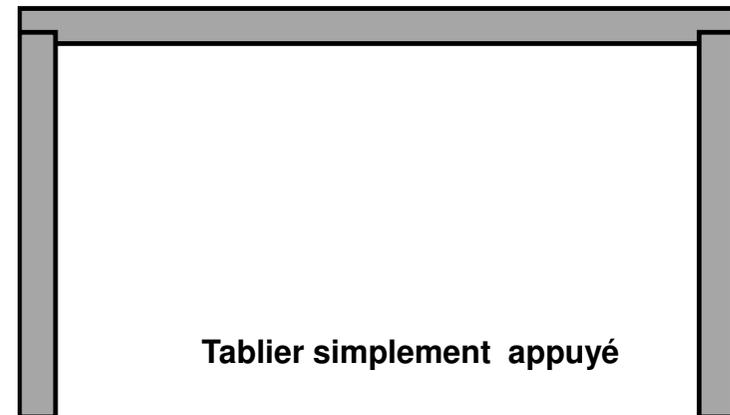
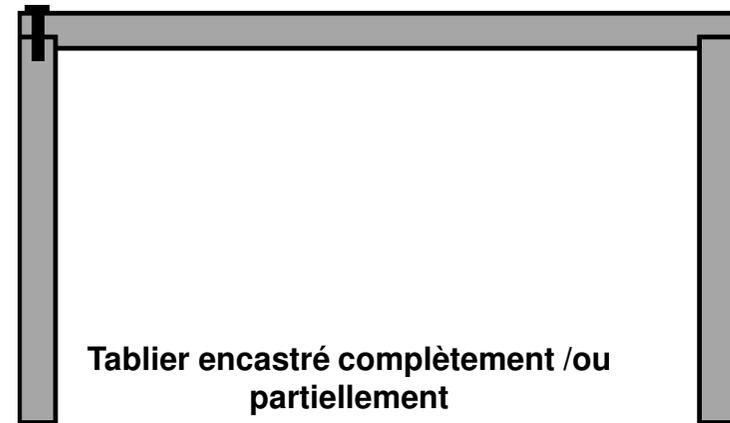
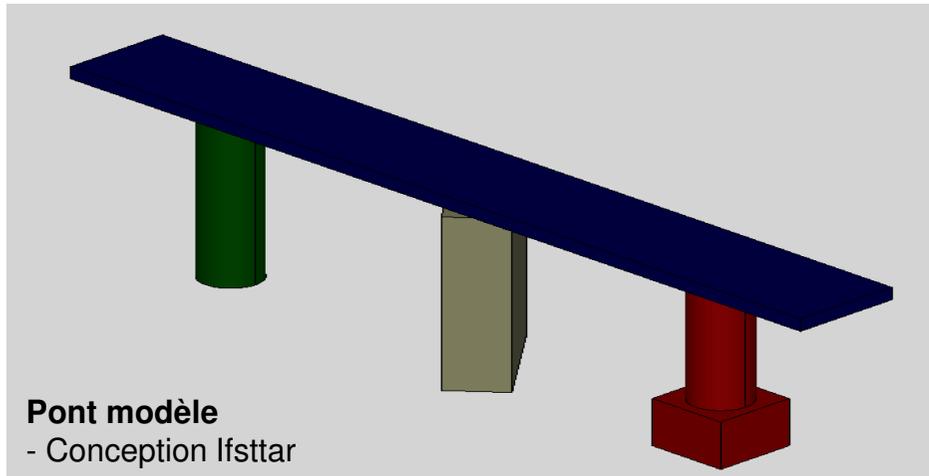
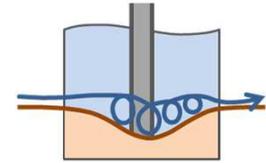
- Invariance de spectres selon la hauteur d'eau (à Q=50L/s)

- Accès à l'amortissement

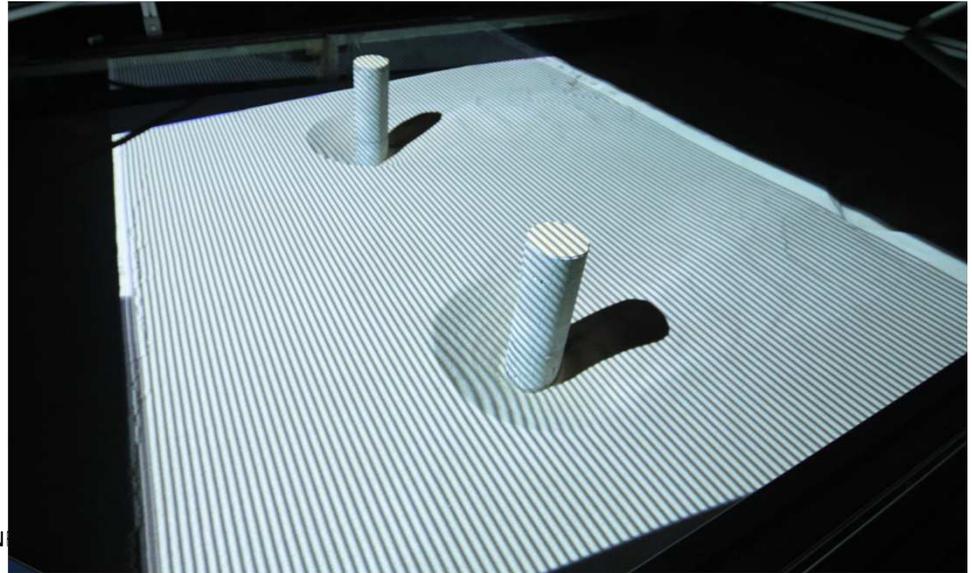
Boujia et al., *Infrastructure*, 2019

Boujia et al., *Sensor*, 2019 (submitted)

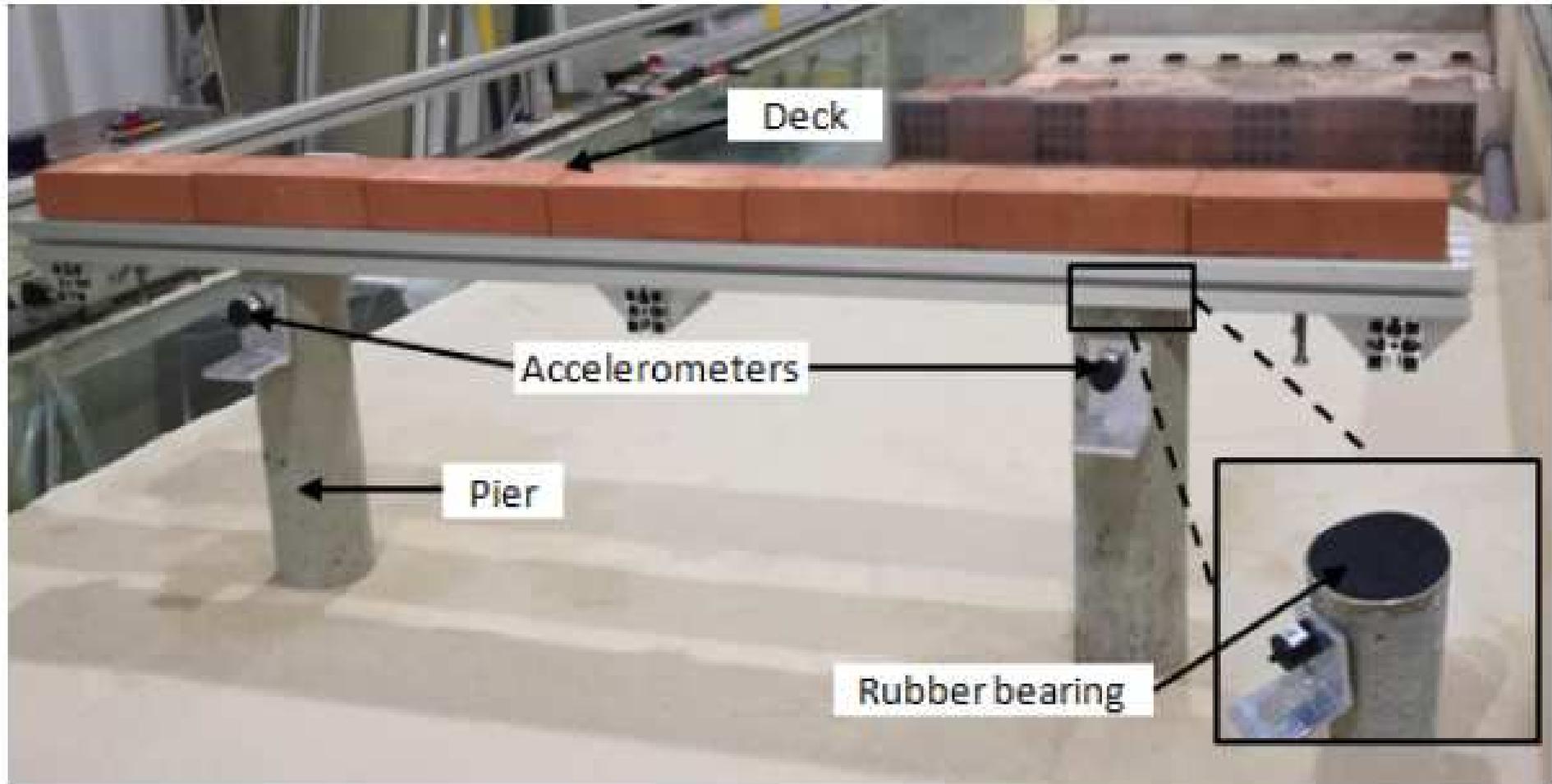
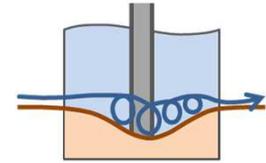
2.3. Ouvrage modèle



2.3. Ouvrage modèle



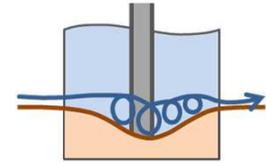
2.3. Ouvrage modèle



Boujia et al., *Infrastructure*, 2019

Boujia et al., *Sensor*, 2019 (submitted)

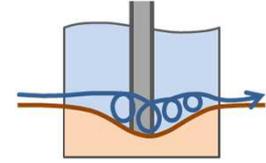
Résumé - conclusions



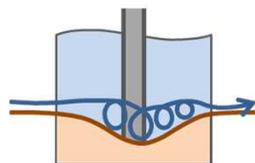
- **Nouveau modèle physique**
 - Affouillement sur ouvrage modèle
 - Pile de fondation cylindrique avec ou sans semelle
 - Tablier à une travée en appui simple
 - Mesure bathymétrique à Moiré 2VP-1C pour couvrir les zones d'ombres du montage 1VP-1C
 - Mesure acoustique de vitesse

- **Résultats**
 - Calibration de la méthode Moiré 2VP-1C
 - Critère '*clear water*' et '*lived bed*' scour du canal C22
 - Analyse vibratoire sur une tige 'scour depth sensor' (SDS) et sur une pile
 - Analyse vibratoire sur un ouvrage modèle

Résumé - conclusions

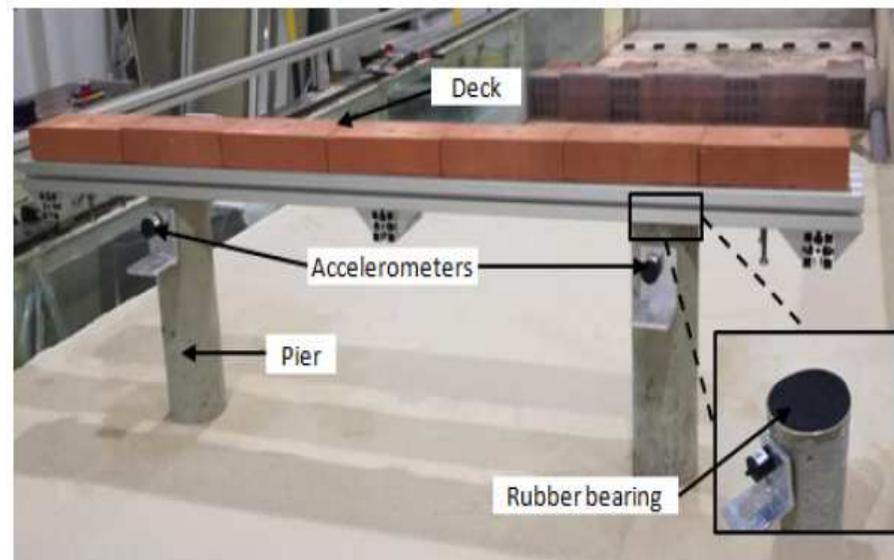


- **Collaboration inter-partenaires et inter-tâches**
 - Tâche 2
 - Prêt et test de Moiré sur expérimentation du FAST
 - Comparaison de méthodes pour la vélocimétrie avec le FAST
 - optique (PIV) et acoustique (ADVP)
 - Piles en béton fabriquées par Ifsttar
 - Tâche 3
 - Analyse vibratoire avec Ifsttar et Railenium
 - Tests pour la métrologie de terrain avec Cerema-Blois, Ifsttar, Railenium
 - Etudiants
 - Jeremy Lonchamp (2017, M2 SIE, U. Paris-Est)
 - Pierre-Louis Gibelin (2018, M2, U. Bretagne Occidental)

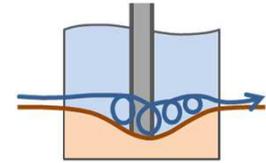


Journée publique de restitution
Mercredi 11 Septembre 2019, Marne-la-Vallée

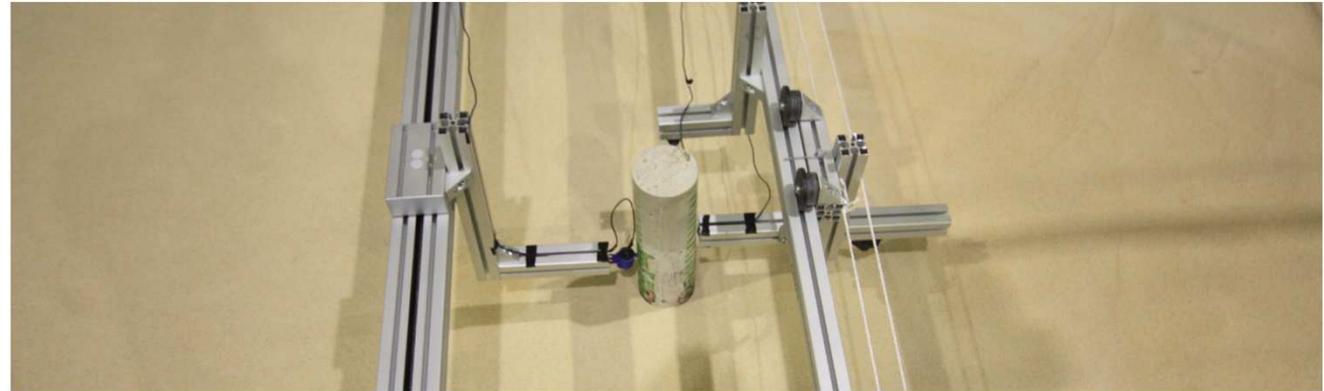
Merci de votre attention.



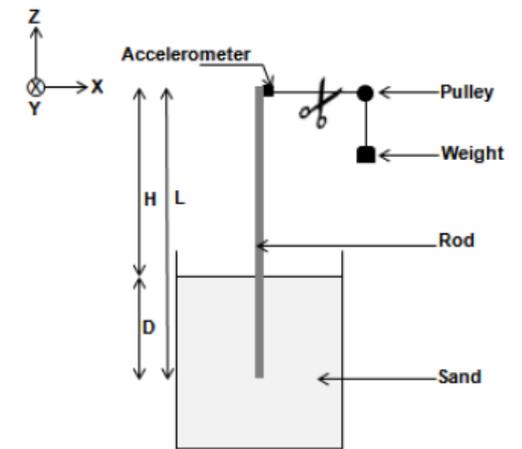
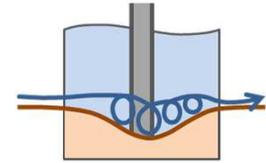
ANNEXES



Limite eau claire-lit vivant	
Débit (L/s)	Hauteur d'eau (cm)
19	6
25	8,5
31	10
35,5	11,2
40	12,2
42	13,1
46	14,1
48,5	15



2.2. Vibration d'une tige et d'une pile



ANNEXES

