



Effect of jet-flipping on scour development downstream of a sluice gate

Chen XIE, Siow-Yong LIM

presented by

Chen XIE

Research student

School of Civil and Environmental Engineering

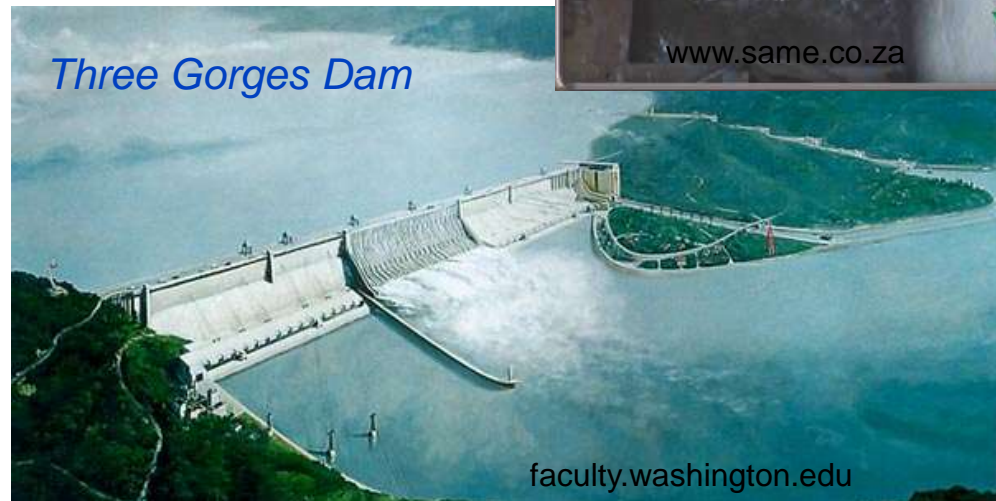
Nanyang Technological University, Singapore

E-mail: xiec0001 @e.ntu.edu.sg

Aug-2012

Outline

- Introduction
- Experimental facilities
- Jet-flipping phenomenon
- Conclusions

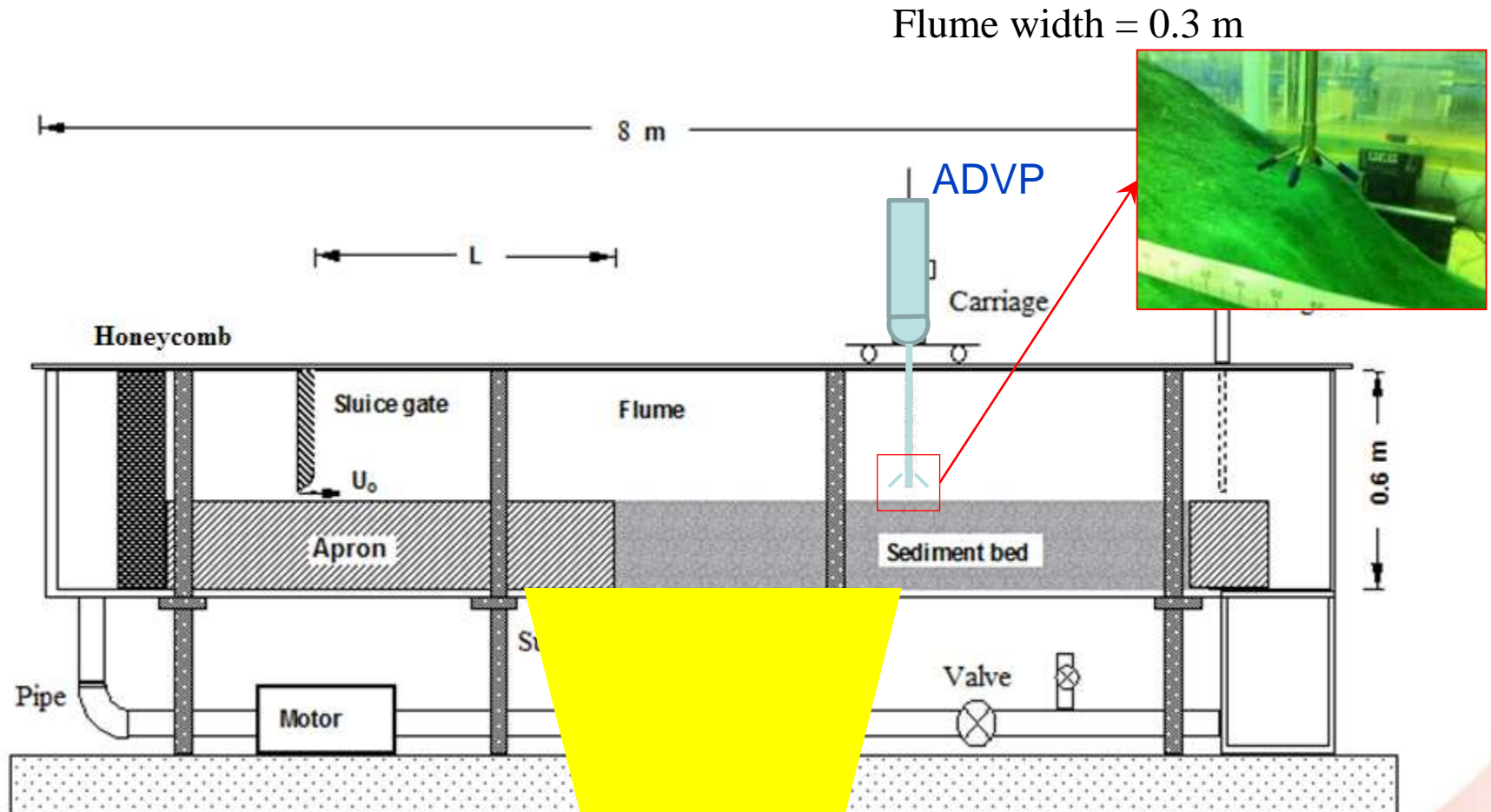


Introduction

- Jets may cause erosion on riverbed and damage the hydraulic structure.
- In the laboratory studies, the scour hole will increase with time and eventually reaches an equilibrium state and most researchers focused on the equilibrium scour state.
- A special jet-flipping phenomenon.
 - Equilibrium state will not be reached
 - Difficult to foresee: Occur intermittent and cyclical
 - May cause inaccurate observations: Distinct scour depth difference



Experimental facilities

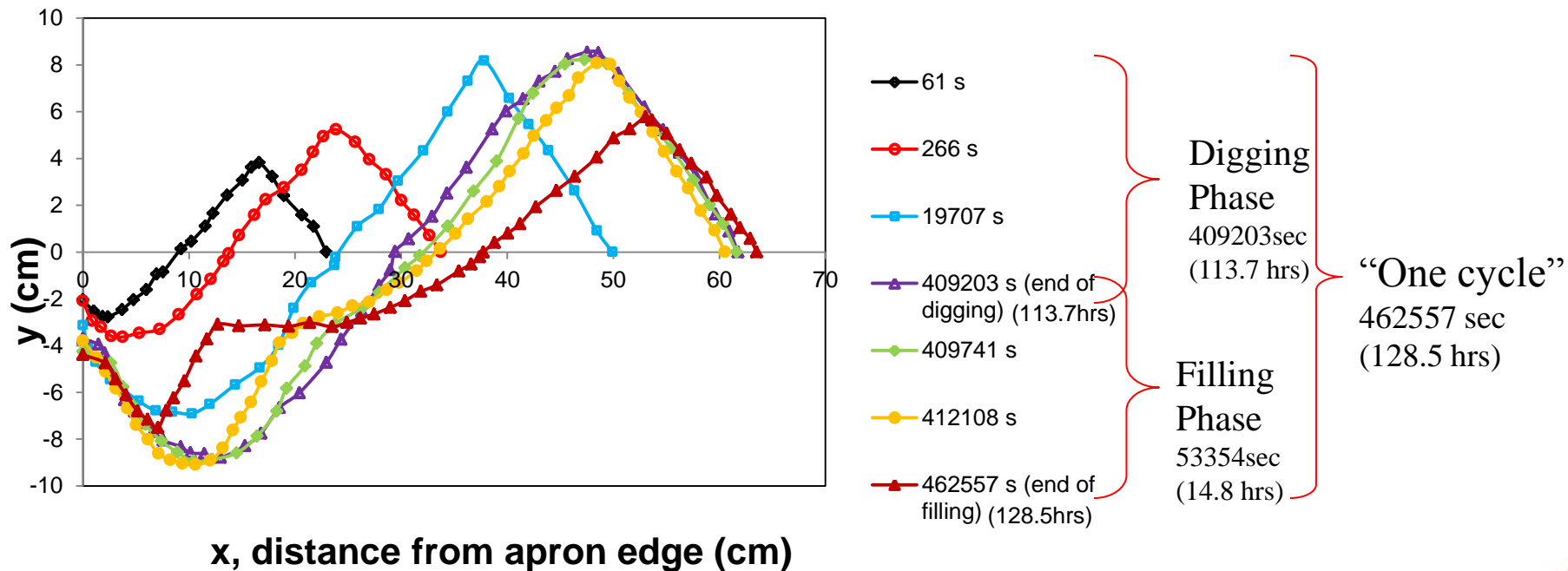


Web camera and computer

Use 2GB hard-disk per day;
Save automatically.

Jet-flipping phenomenon

- Evolution of the scour hole with time

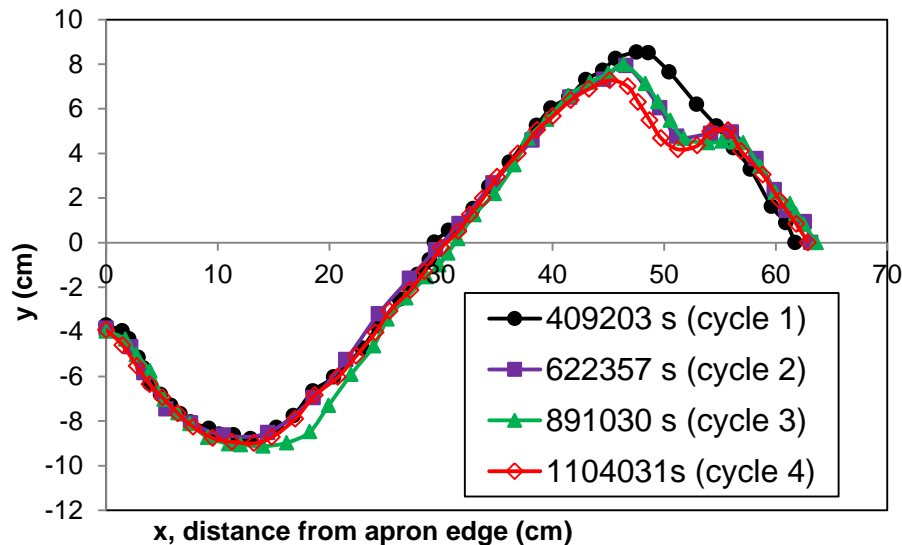


Run79, conducted for 28 days

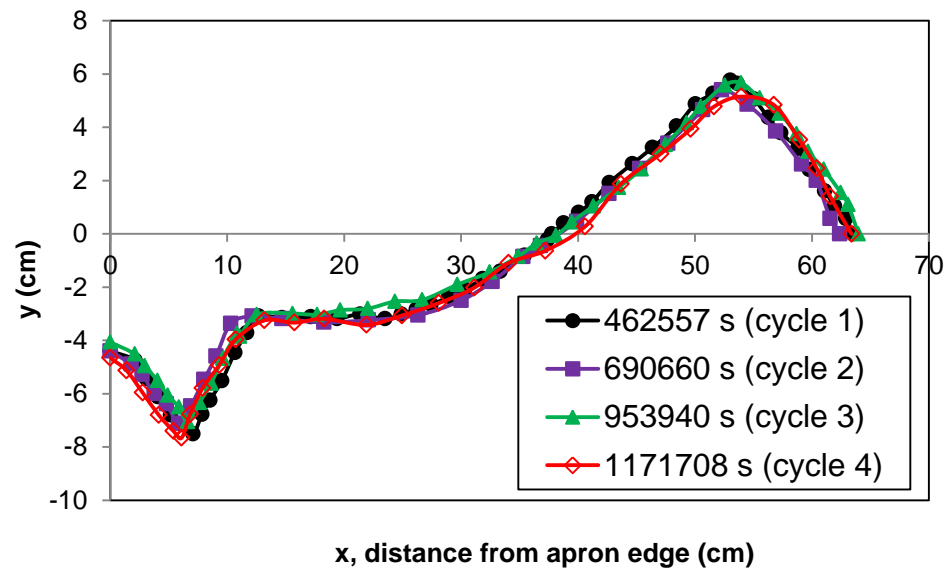
$d_0 = 1 \text{ cm}$, $H_t/d_0 = 12.7$, $L/d_0 = 9$, $u_0 = 0.606 \text{ m/s}$, $F_0 = 5.57$

Jet-flipping phenomenon

- Evolution of the scour hole with time




The end of digging phase for different cycles



The end of filling phase for different cycles

Run79, conducted for 28 days

$d_0 = 1 \text{ cm}$, $H_t/d_0 = 12.7$, $L/d_0 = 9$, $u_0 = 0.606 \text{ m/s}$, $F_0 = 5.57$

Flow direction





Video was speeded up 100 times

Digging phase
 transfers into
 filling phase



about
 5 hrs later

Filling phase
 transfers into
 digging phase

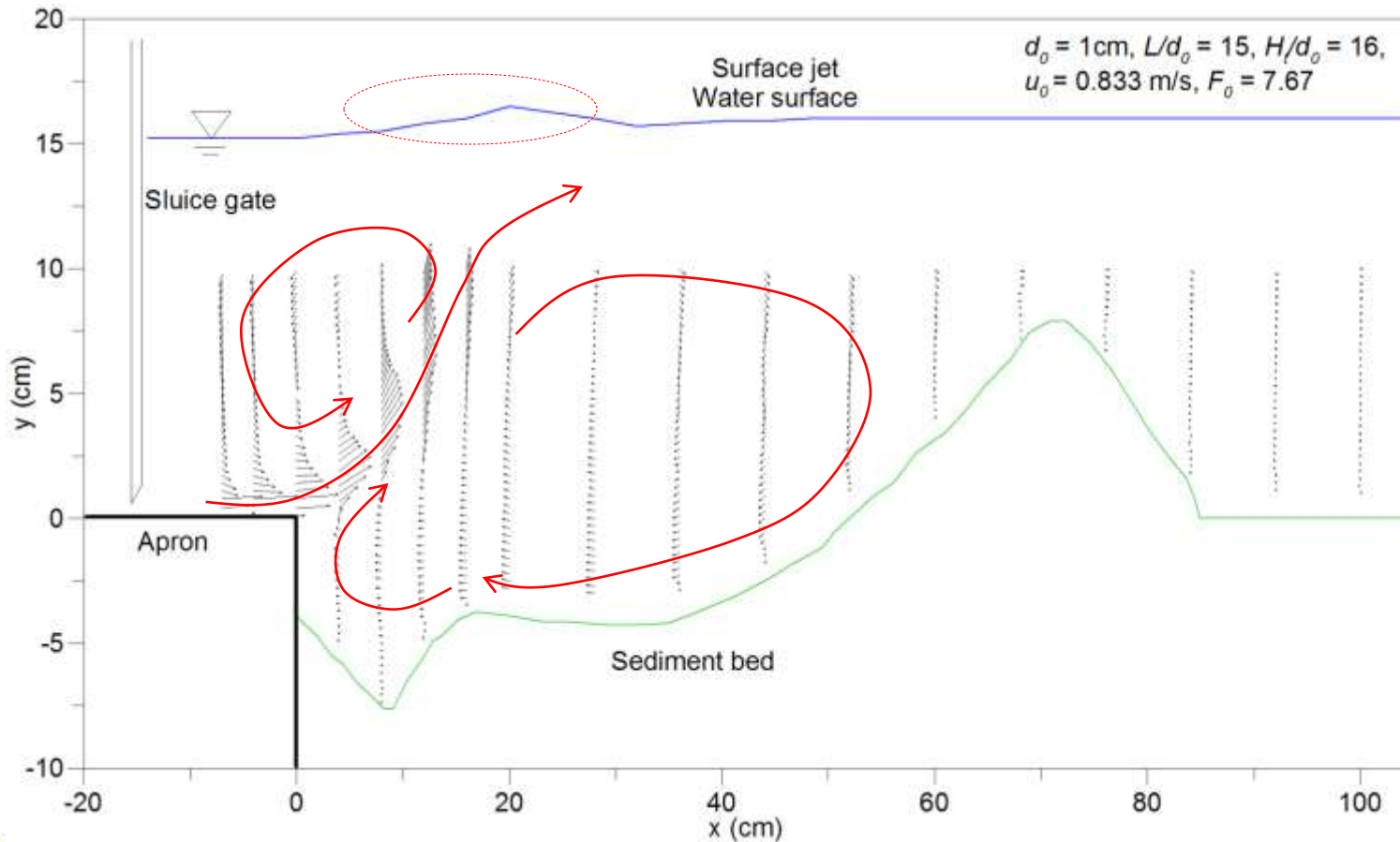
Flow direction




Video was speeded up 10 times

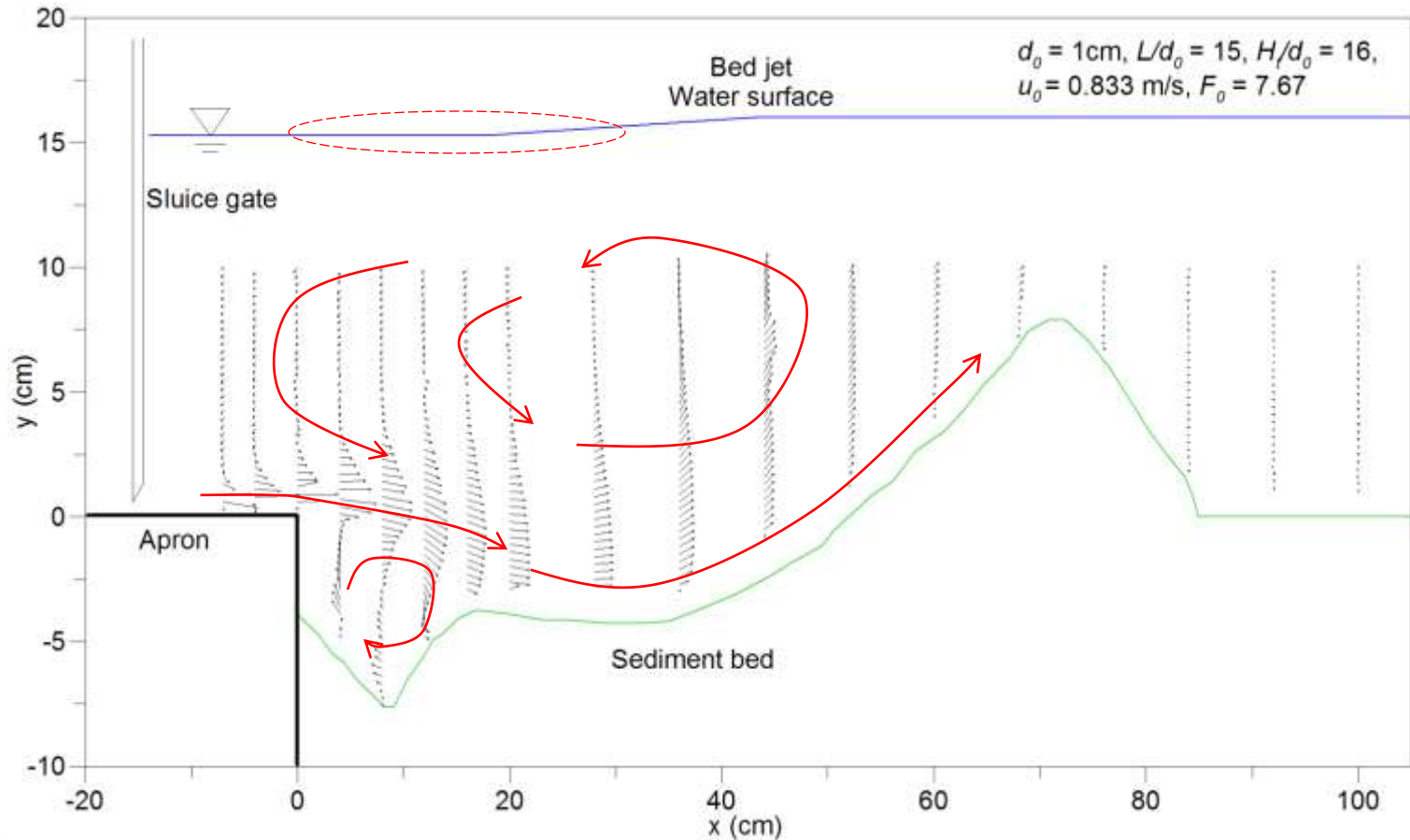
Jet-flipping phenomenon

- Flow field measured by ADVP



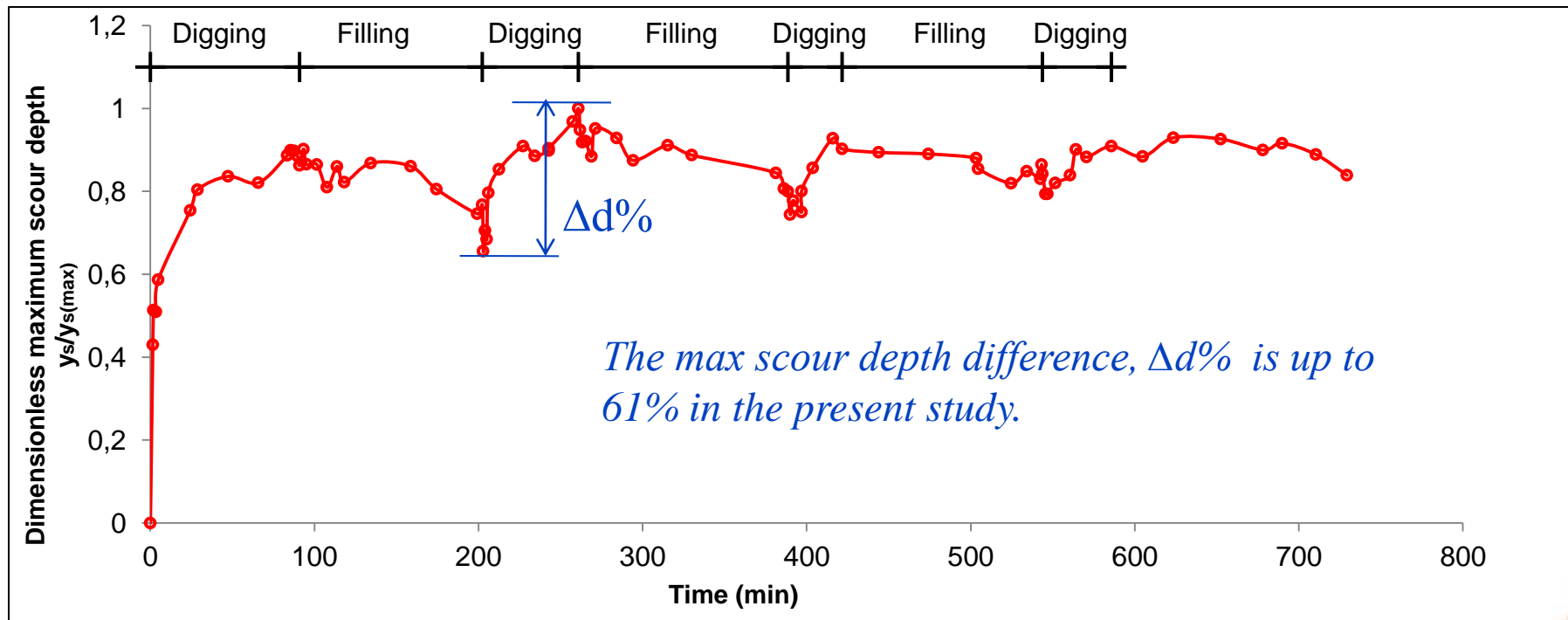
Jet-flipping phenomenon

- Flow field measured by ADVP



Jet-flipping phenomenon

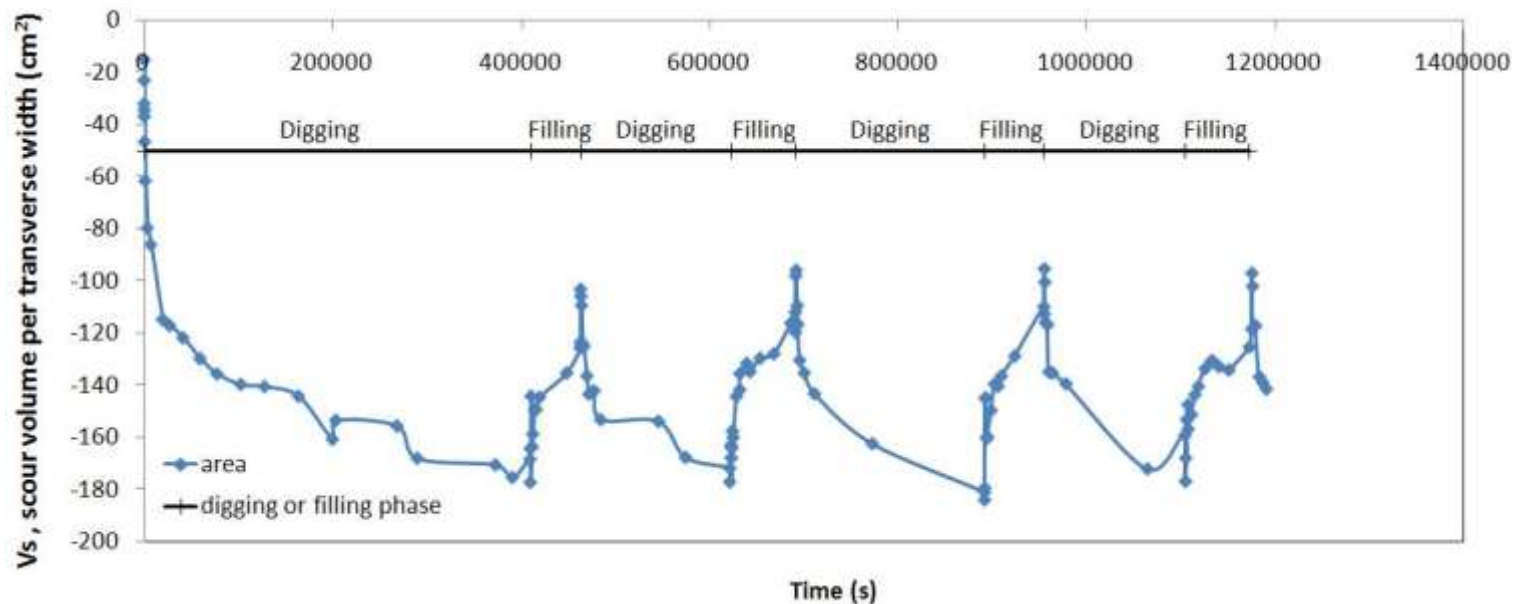
- Characteristic scour geometries



Time variation of the dimensionless scour depth, $y_s/y_{s(max)}$ of Run13, which was conducted for 7 days with $d_0 = 1$ cm, $H_t/d_0 = 12.7$, $L/d_0 = 21$, $u_0 = 0.710$ m/s, $F_0 = 6.53$

Jet-flipping phenomenon

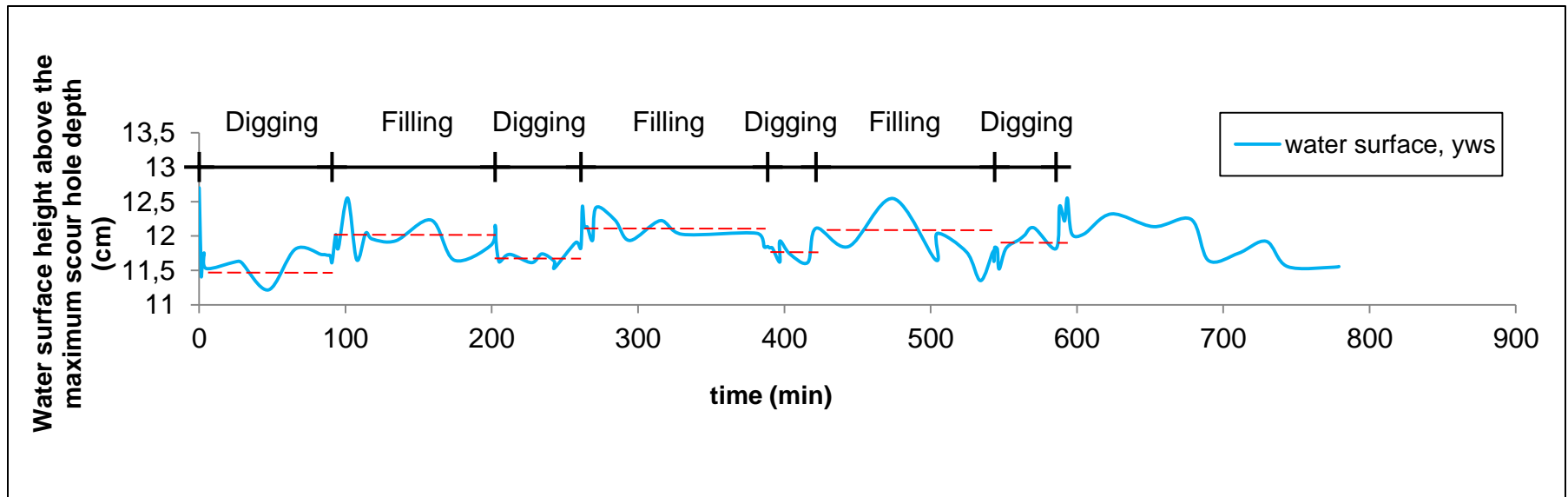
- Characteristic scour geometries



Variation of scour hole volume per unit width with time of Run 79

Jet-flipping phenomenon

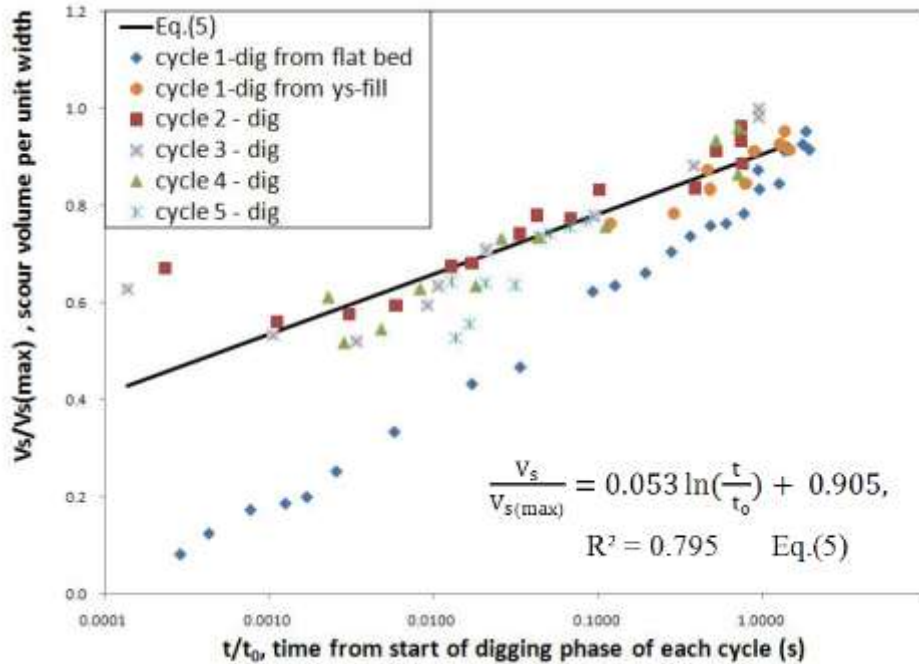
- Characteristic scour geometries



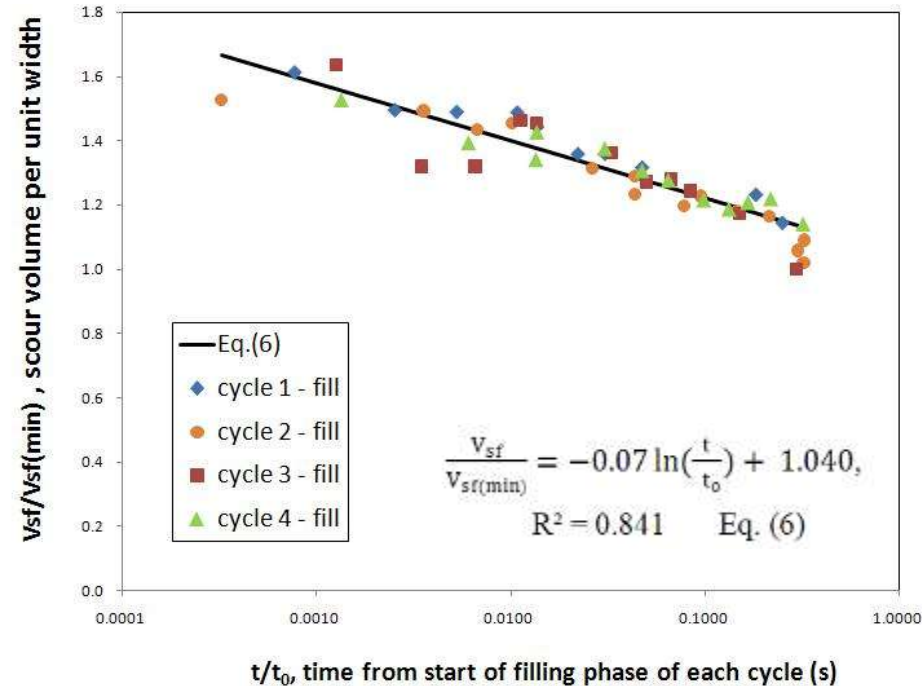
Time variation of the water surface height above the maximum scour location of Run13

Jet-flipping phenomenon

- Variation of the scour volume with time of Run 79



Digging phases of different cycles



Filling phases of different cycles

(t_0 is the average time to complete one cycle)

Conclusions

- For certain hydraulic conditions, no equilibrium scour state was observed because of a **jet-flipping phenomenon** during the local scouring process by 2-D wall jets.
- Two **cyclical** phases, the **digging phase** with bed jet and calm water surface, and **filling phase** with surface jet and wavy water surface, occurred alternately.
- The scour profiles at the end of the digging and filling phases remained **almost the same** even though there were many different cycles in a test run.
- The scour characteristic geometries, i.e. the maximum scour depth, the volume of the scour hole and water surface height were observed to **change in cycle** in accordance with the digging and filling phases. The maximum **scour depth difference** between these two phases studied so far can be as much as 61% which should be considered in practical application.

Thank you!

E-mail: xiec0001@e.ntu.edu.sg

Experimental facilities

- Bed sediment

- Non-cohesive
- Specific gravity: 2.65
- Sediment bed thickness: 20 cm
- Type 1: Uniform sand ($\sigma_g = 1.12$), $d_{50} = 0.73$ mm
- Type 2: Non-uniform sand ($\sigma_g = 1.60$), $d_{50} = 0.29$ mm



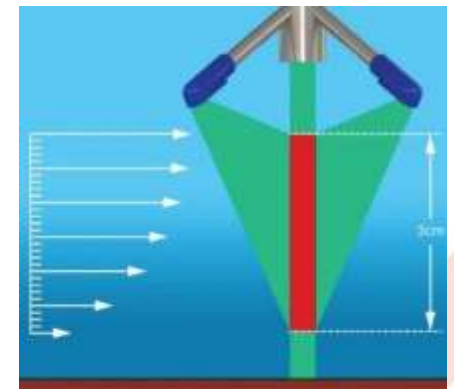
- ADVP (Norteck Vectrino II)

- Three-component velocity
- 3 cm range up to 31 points
- Resolution: 1 mm
- Sampling rate: 100 Hz



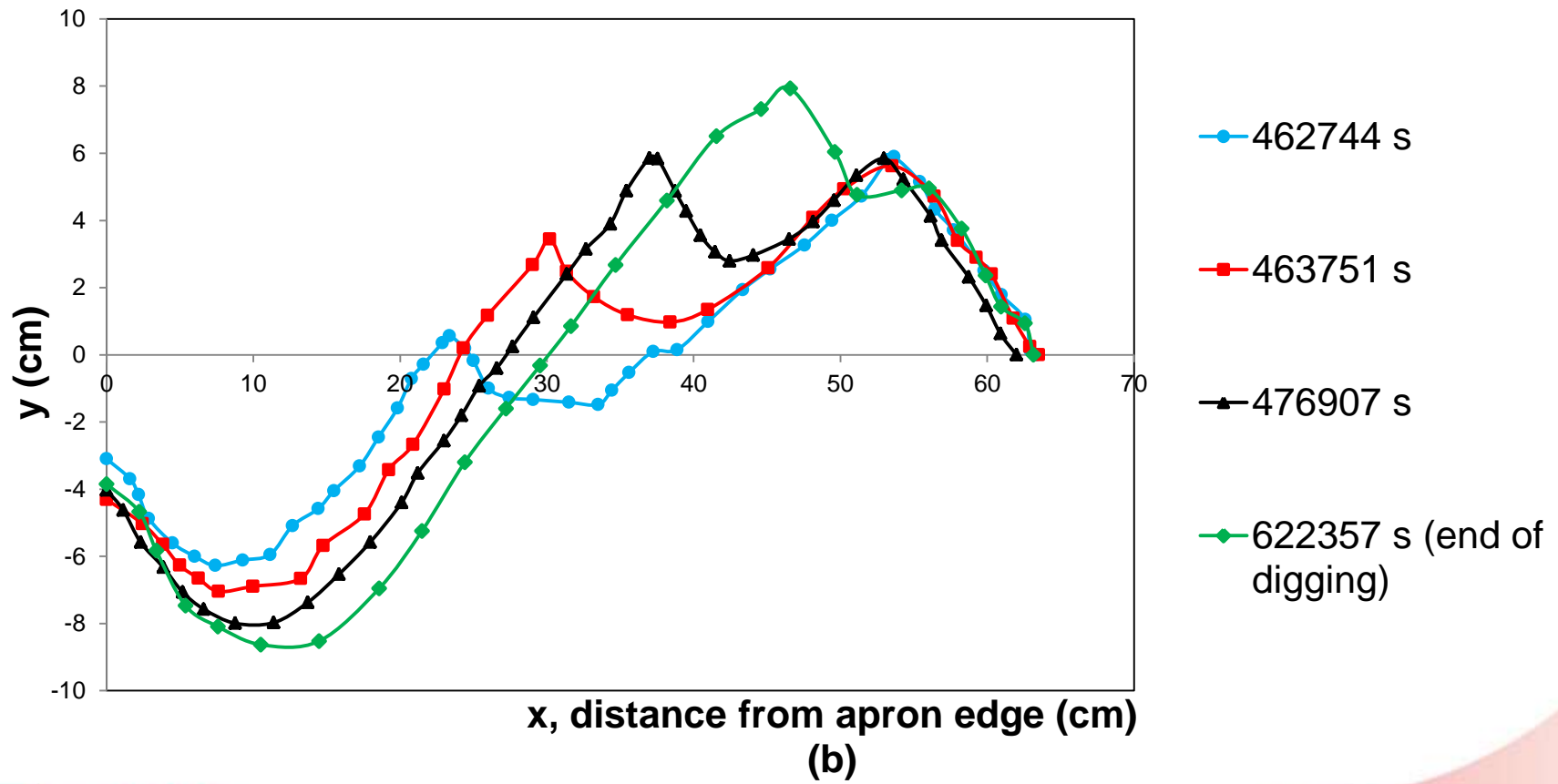
- Web camera (Connected to a computer)

- Record continuously, long period
- Resolution: up to 800*600 pixels
- Video software: automatically save at every hour
- Hard disk storage: 2GB per day



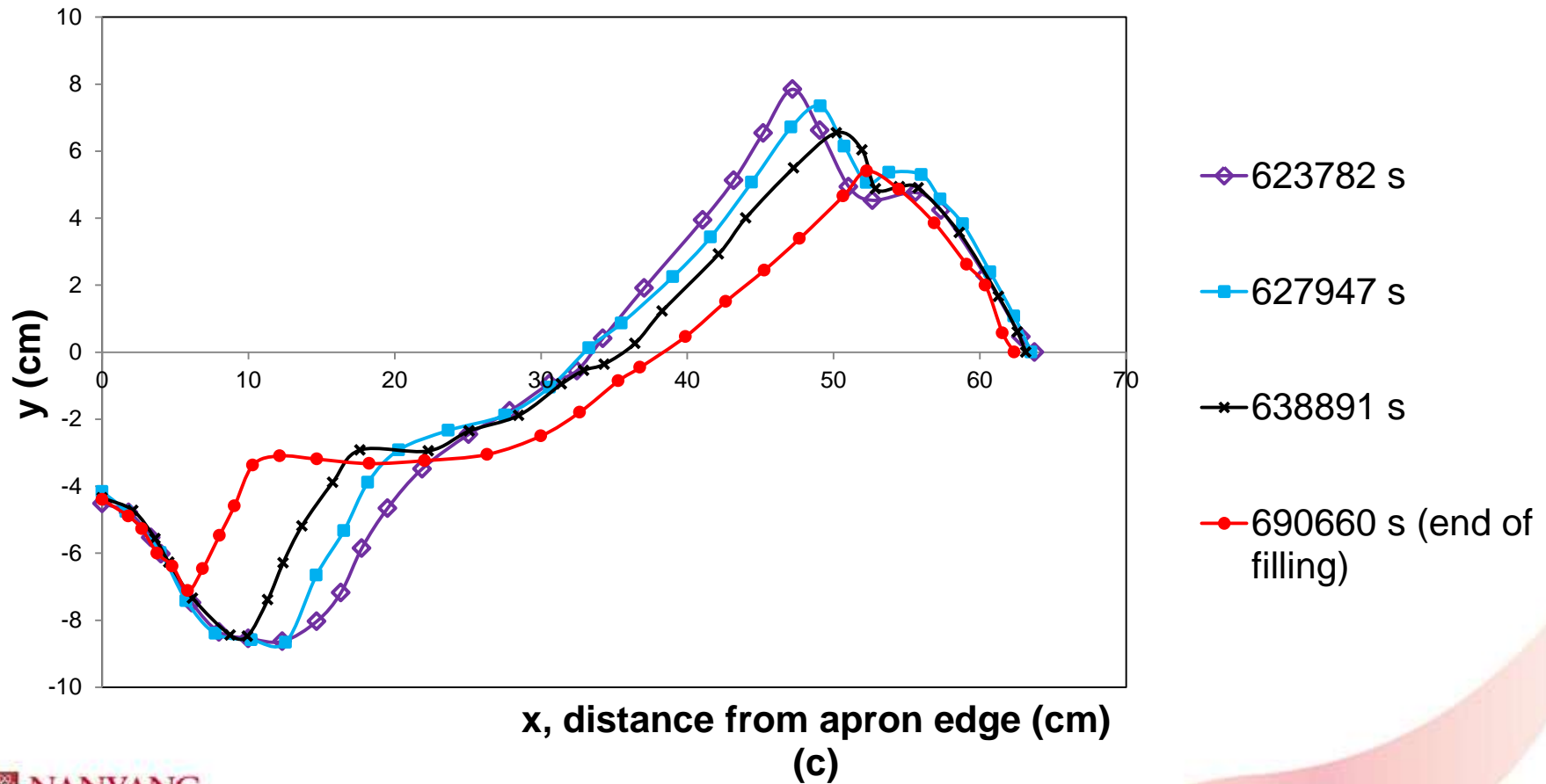
General observations

- Evolution of the scour hole with time



General observations

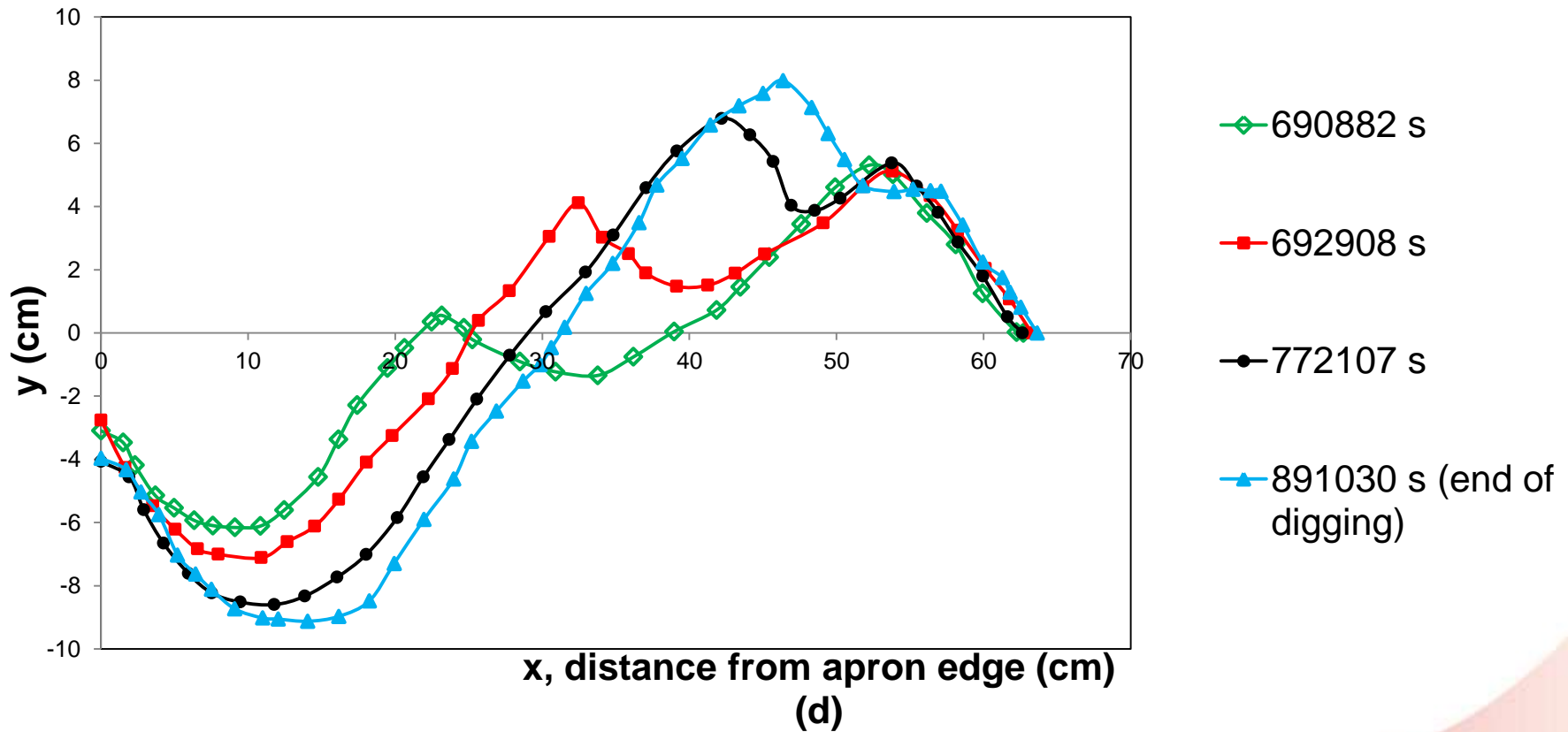
- Evolution of the scour hole with time



A filling phase in Cycle 2nd

General observations

- Evolution of the scour hole with time



A digging phase in Cycle 3rd

