

Experimental study of flowing nappe oscillations

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Goals of the study :

- ✓ To deepen the understanding of the physical mechanism underlying weir nappe oscillations;
- ✓ To identify the range of geometric and hydraulic parameters which produce nappe oscillations;
- ✓ To quantify the scale effects in nappe vibration experimental modeling.

Characterization of Nappe Oscillations

2 Procedures:

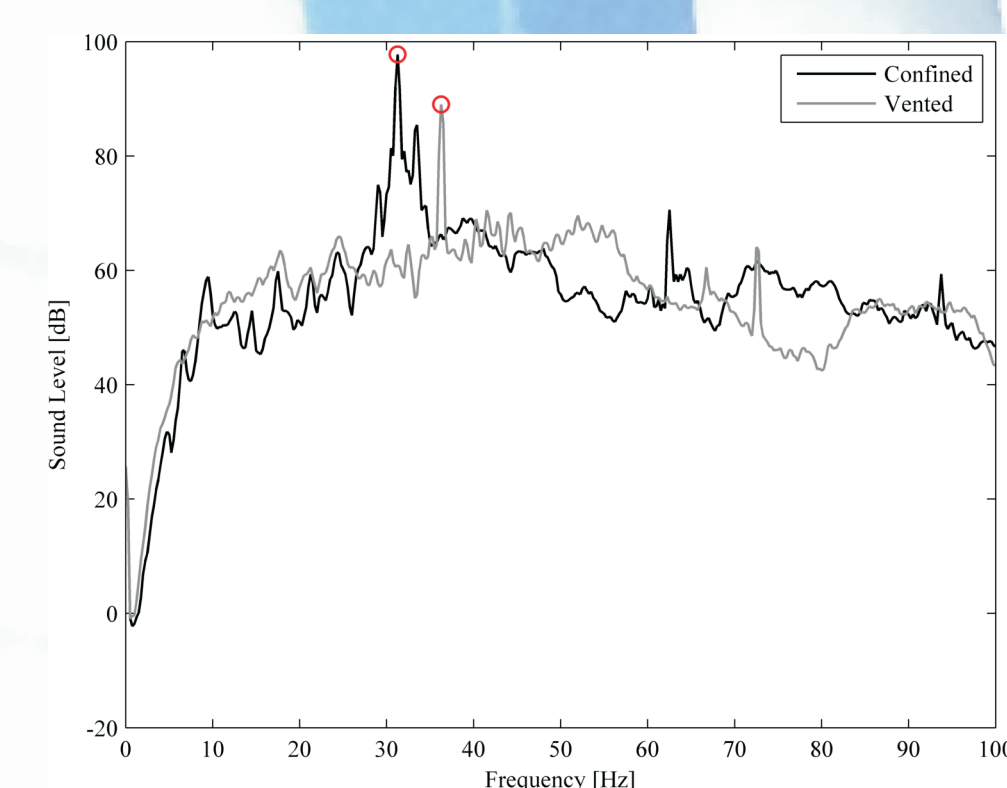
- ✓ Sound measurement analysis
- ✓ Image analysis

Results :

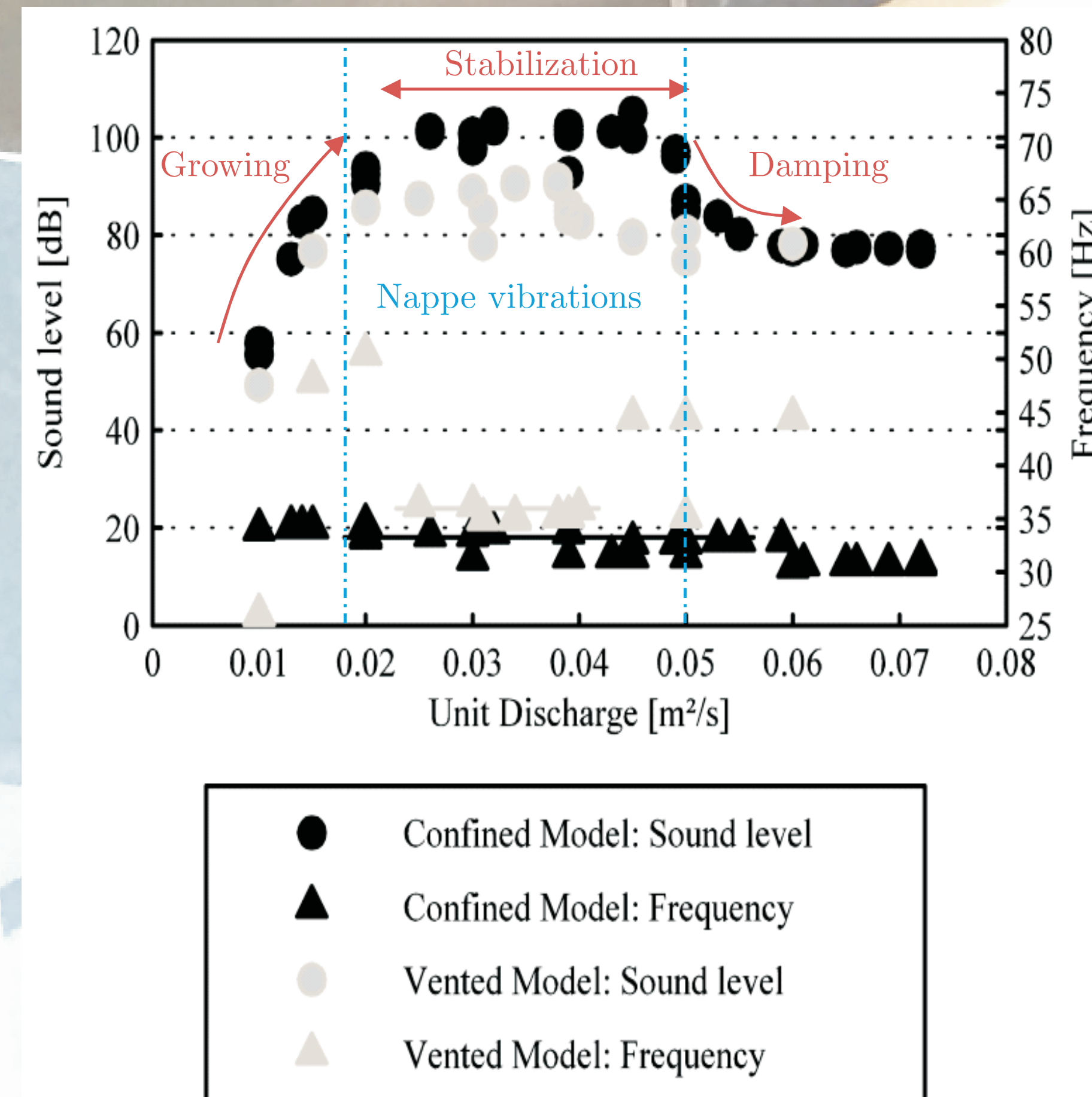
- ✓ Detection of dominant frequencies and associated sound level based on sound recordings
- ✓ Calculation of horizontal wave frequency based on image analysis



Flow visualization ($0.03 \text{ m}^2/\text{s}$ - quarter round crest - confined model) : Detection of horizontal bands



Audio spectrum of sound recording ($0.03 \text{ m}^2/\text{s}$ - quarter round crest) : Detection of dominant frequency



Observed nappe oscillations at Linville Land Harbor Dam (USA) - Crookston et al. (2014)

Parametric study

3 crest shapes (crest radius of 15cm):

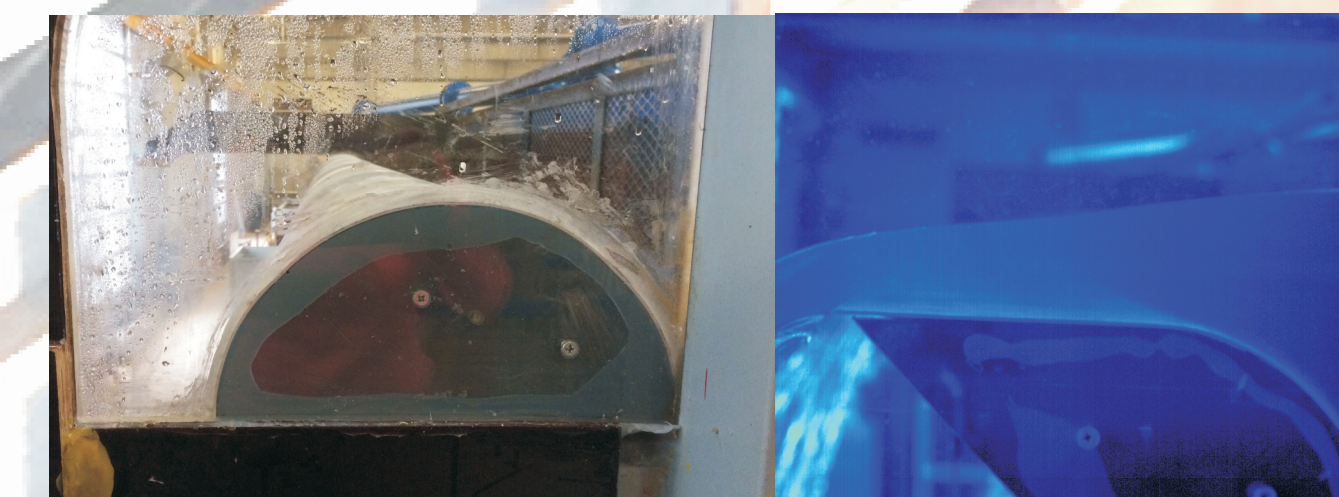
- ✓ Quarter round crest
- ✓ Half round crest
- ✓ Three-quarter round crest

Geometrical parameters :

- ✓ Width = 3.46 m, 2.45 m, 1.45 m and 1.00 m
- ✓ Chute height = 3.0 m, 1.0 m and 0.5 m
- ✓ Confinement

Measurements :

- ✓ Sound
- ✓ Flow visualization



Half and quarter rounded crests



Prototype-scale linear weir model

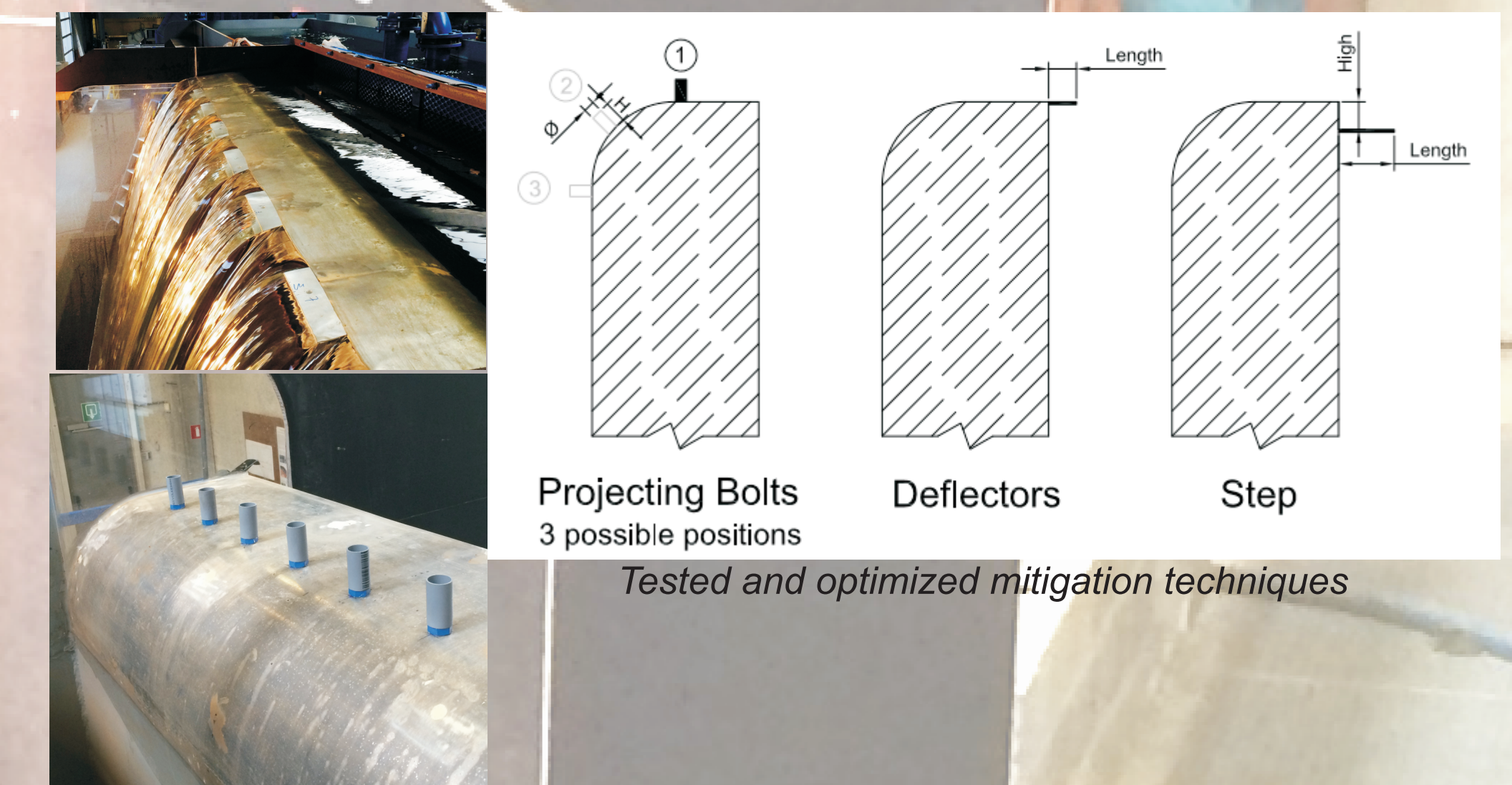
Mitigation techniques

3 crest modifications:

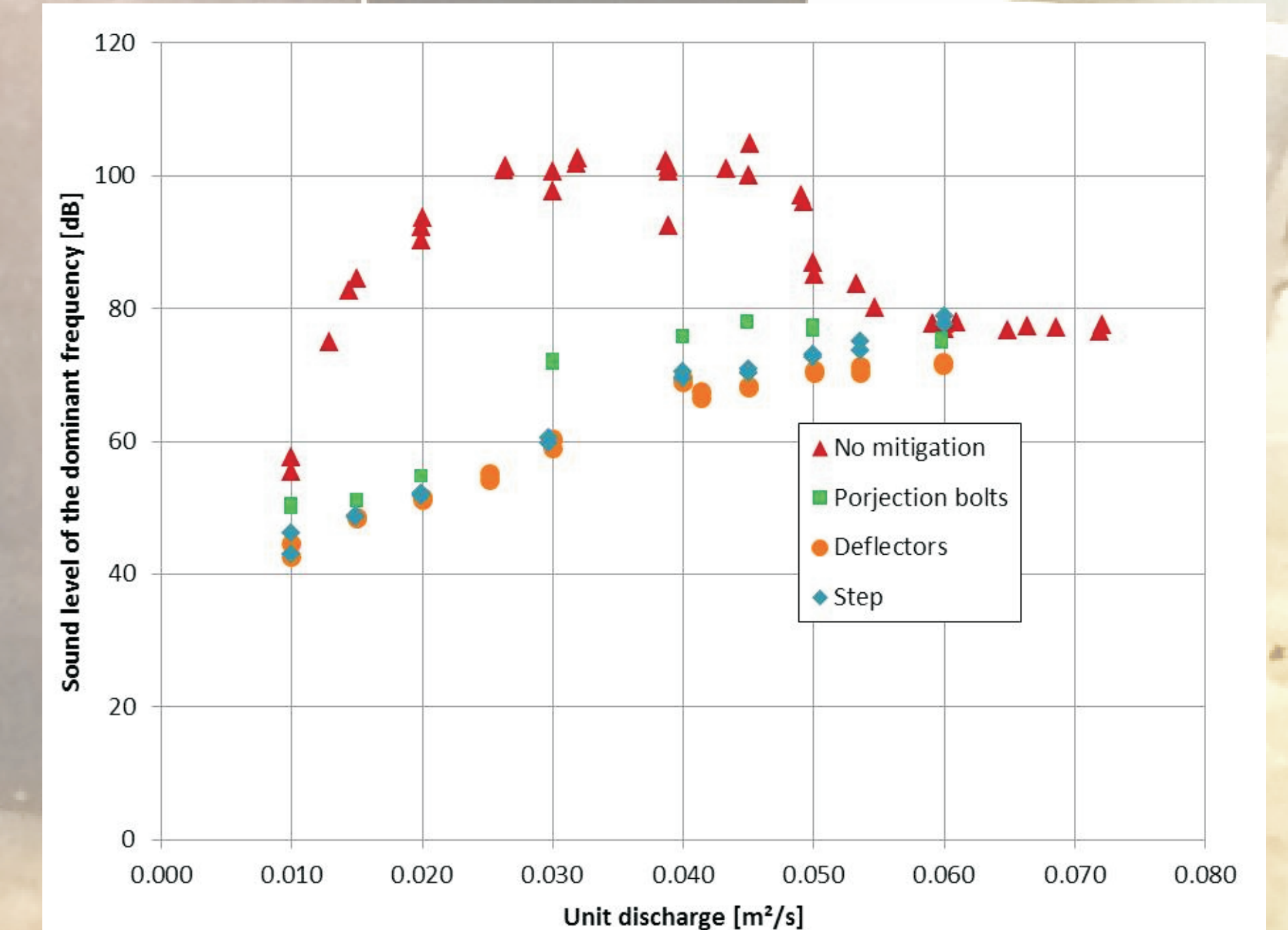
- ✓ Projecting bolts
- ✓ Deflectors
- ✓ Step

Other mean geometrical parameters are conserved :

- ✓ Width = 3.46 m
- ✓ Chute height = 3.0 m
- ✓ Confined model



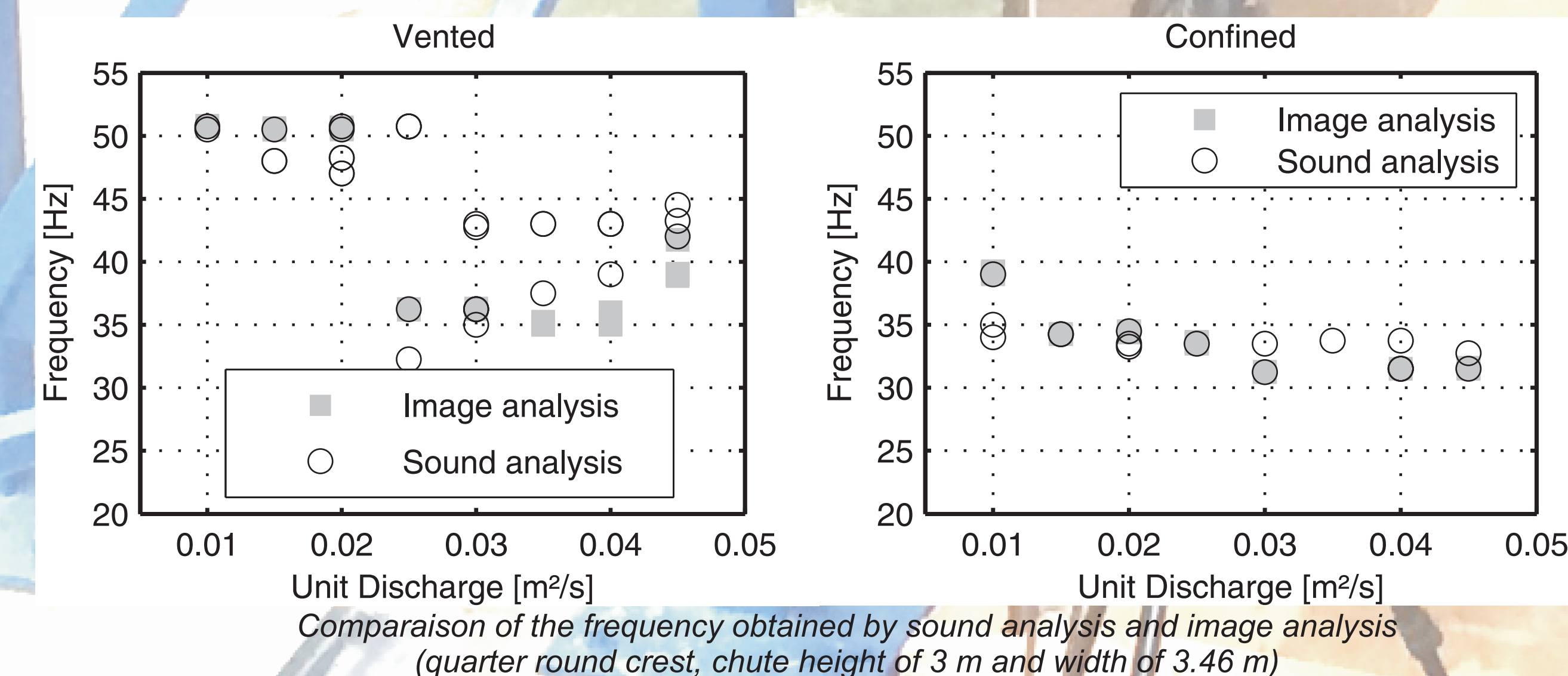
Tested and optimized mitigation techniques



Evolution of sound level of the dominant frequency with unit discharge for optimized mitigation techniques (quarter round crest - confined model)

Characteristics of the model :

- ✓ Prototype-scale linear weir model : maximal weir length of 7 m and fall height of 3 m.
- ✓ Air cavity behind the nappe confined or vented to the atmosphere (back wall and lateral walls in multiplex panels or Plexiglas).
- ✓ Baffle wall of synthetic membranes assuring a uniform velocity profile upstream of the model.
- ✓ 2 pumps delivering discharges between 0 and 250 l/s measured with an electromagnetic flowmeter.
- ✓ Nappe vibration characterization by means of a microphone and high-speed video camera.



Observed nappe oscillations at Nisramon Dam (Belgium)