Cyclic loading of suction caisson foundations for offshore wind turbines

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Offshore wind power

- Introduction
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- Analysis
- Conclusions

Offshore wind turbines in the UK

- Government renewable energy policy

  10% of electricity by 2010 from clean energy ($6 \cdot 10^3$MW)

  32 turbines currently working (64MW)

- Why suction caisson foundations? (for 5MW turbines)

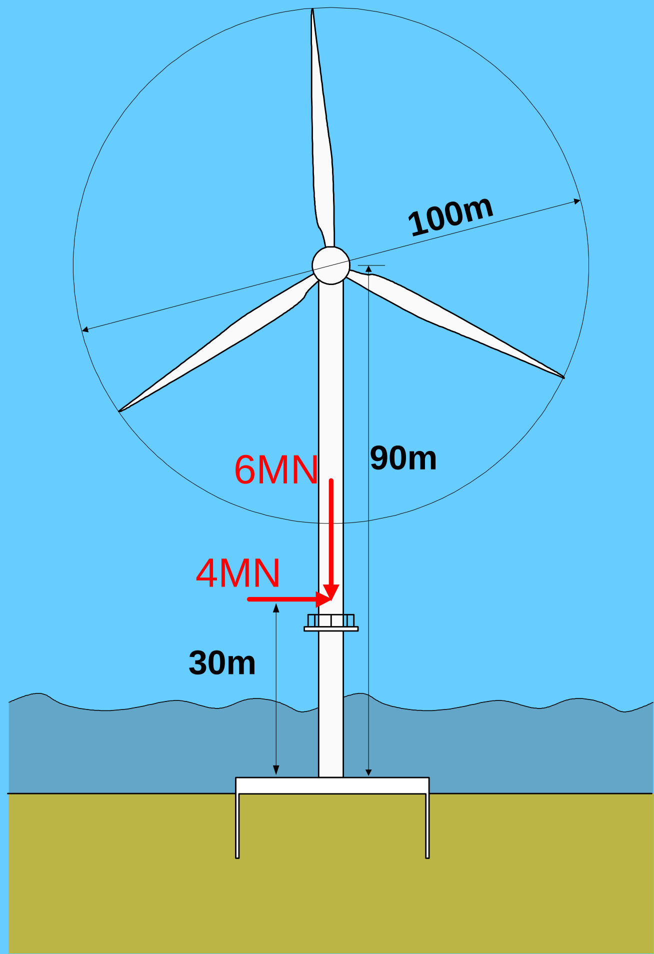
  Gravity bases become very large in size and in weight

  Piles require expensive equipment and long time for installation

Motivation

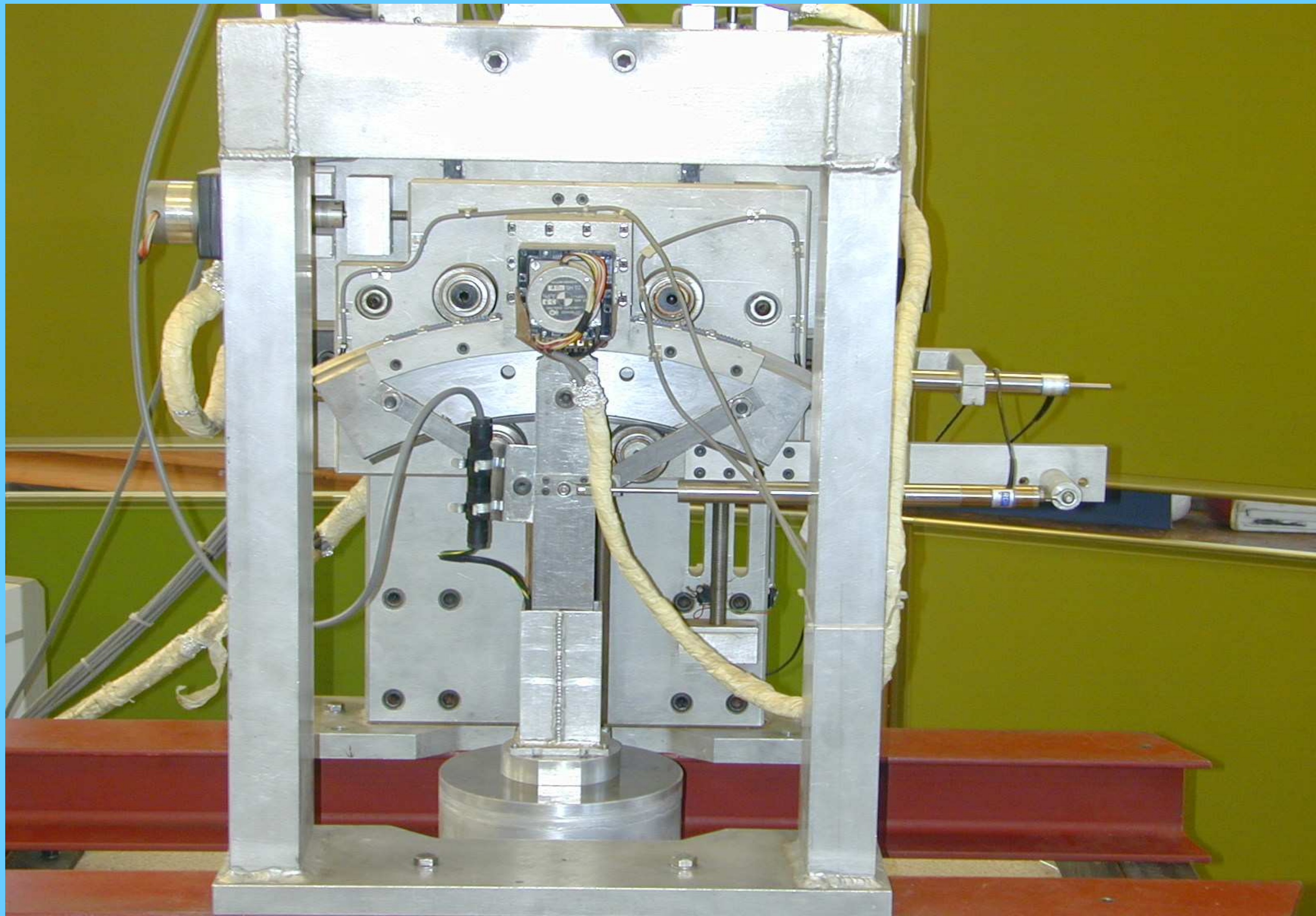
North Hoyle wind farm (2003)

http://www.bwea.com/media/images/NorthHoyle©AnthonyUpton2003.jpg

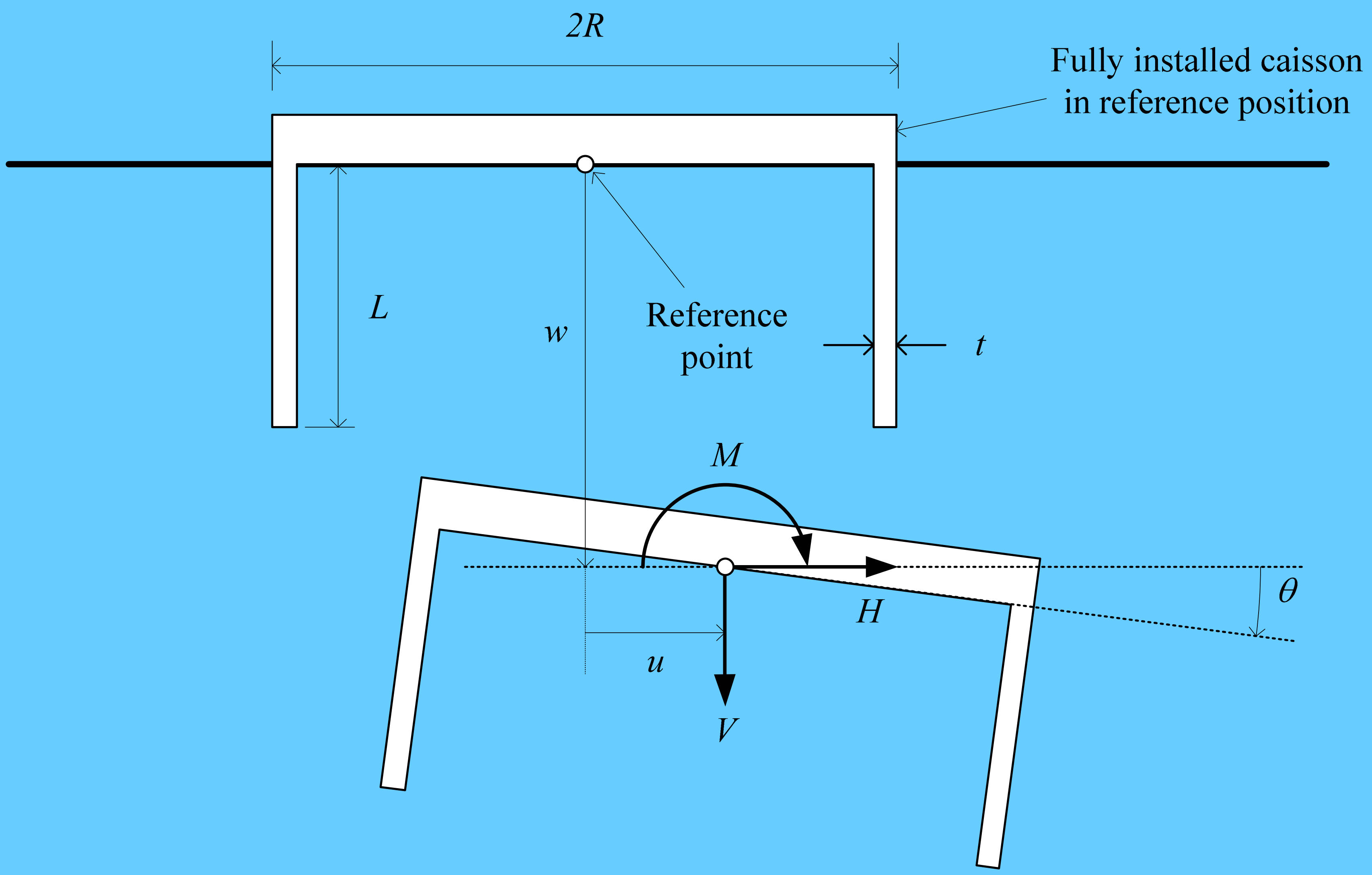


Proposed monopod suction caisson foundation

3DOF rig



Loads and displacements in the reference point

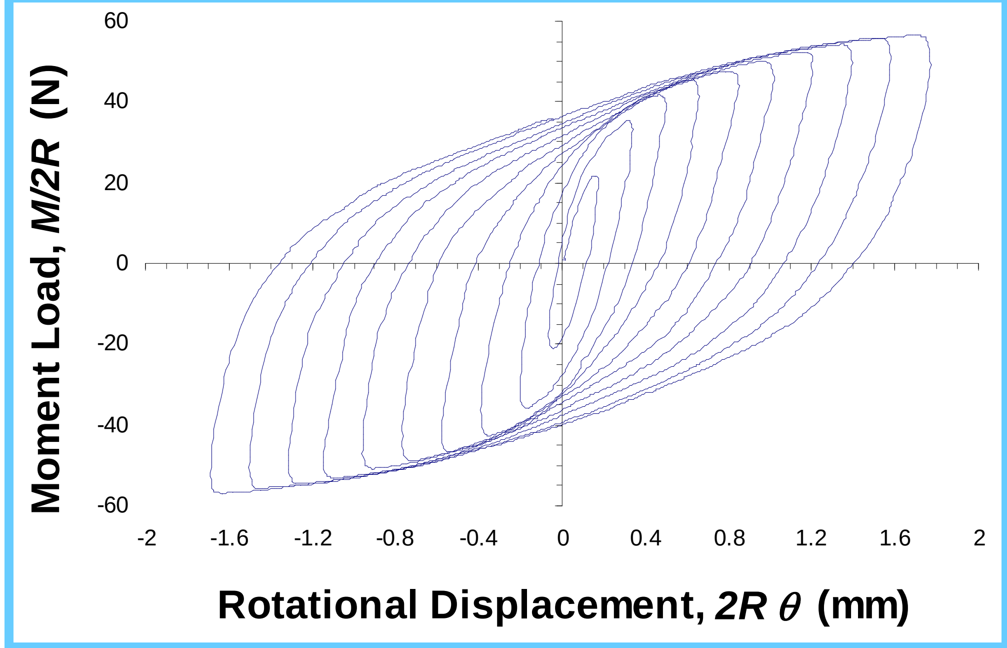


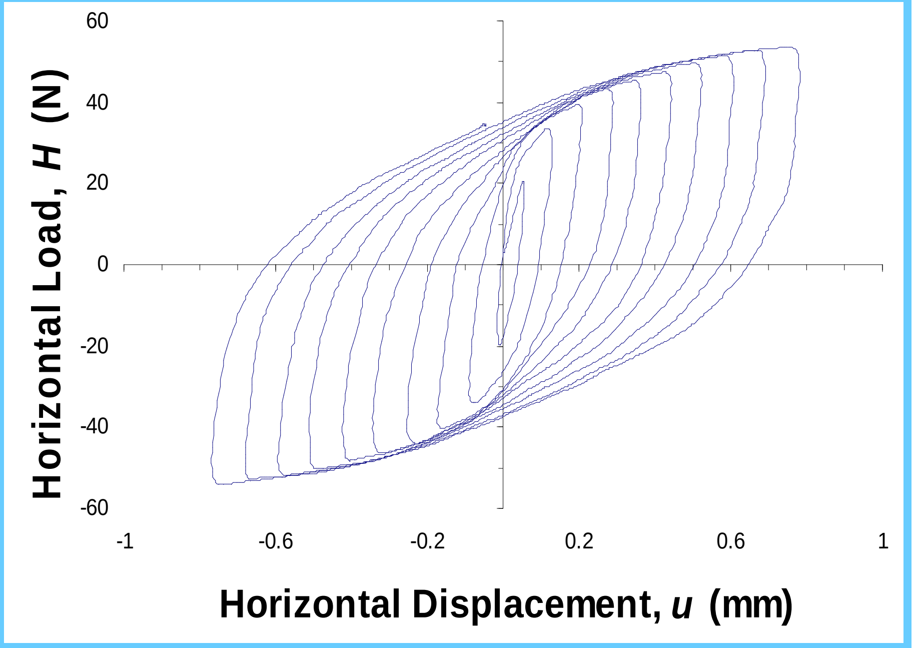
Description of the tests carried out

- Two models of suction caissons:
  1) $2R = 293$mm, $L = 150$mm, $t = 3.4$mm ($L/2R = 0.5$)
  2) $2R = 202$mm, $L = 200$mm, $t = 3.4$mm ($L/2R = 1$)
- Dry and loose white Leighton Buzzard sand:
  1) $Rd = 26\% \pm 13\%$ ($L/2R = 0.5$)
  2) $Rd = 20\% \pm 3\%$ ($L/2R = 1$)
- Constant *V*, from -50N to 400N
- Constant ratio $M/2RH$, from -0.1 to 2
- 10 cycles at a velocity $2Rd\theta/dt = 0.02$mm/s

Results

2R = 293mm and *V* = 50N





-Hysteretic response

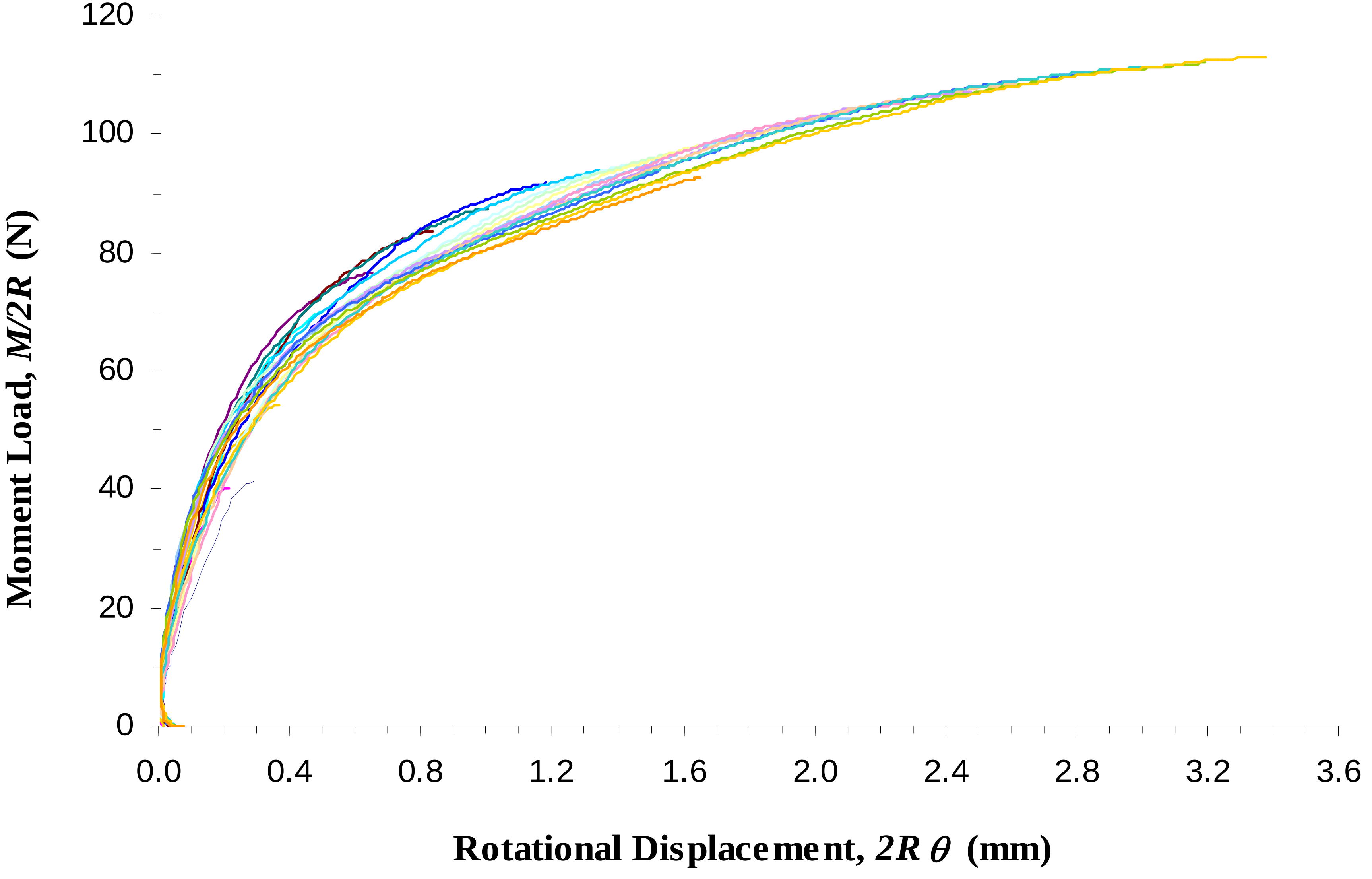
-Masing rule

Masing rule:

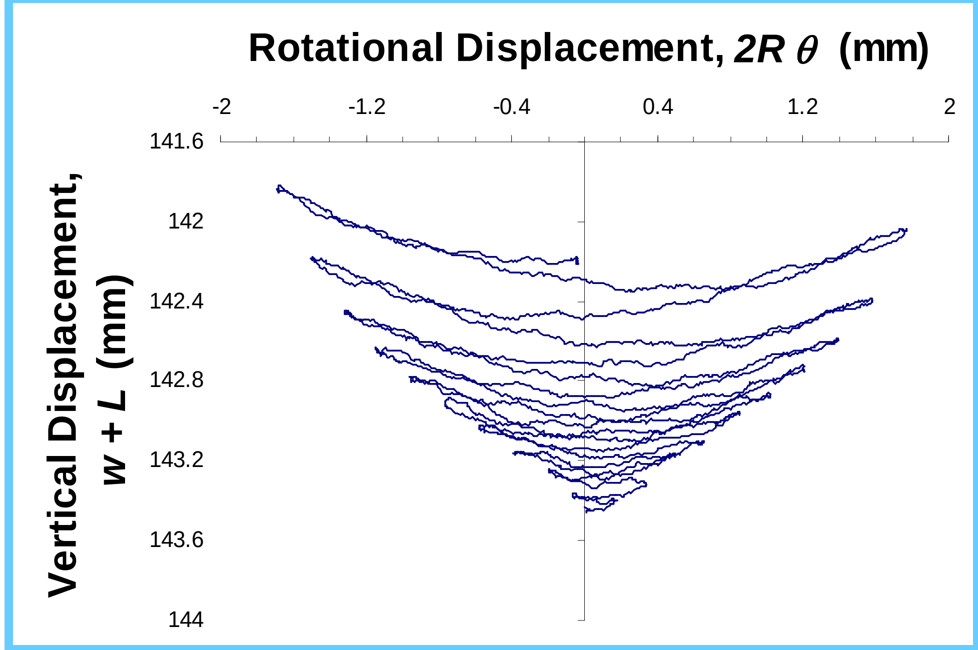
i) the shape of the unloading and reloading curves is the same as that of the doubled initial curve

ii) the tangent slope of the reloading curves is identical to the tangent slope of the initial curve

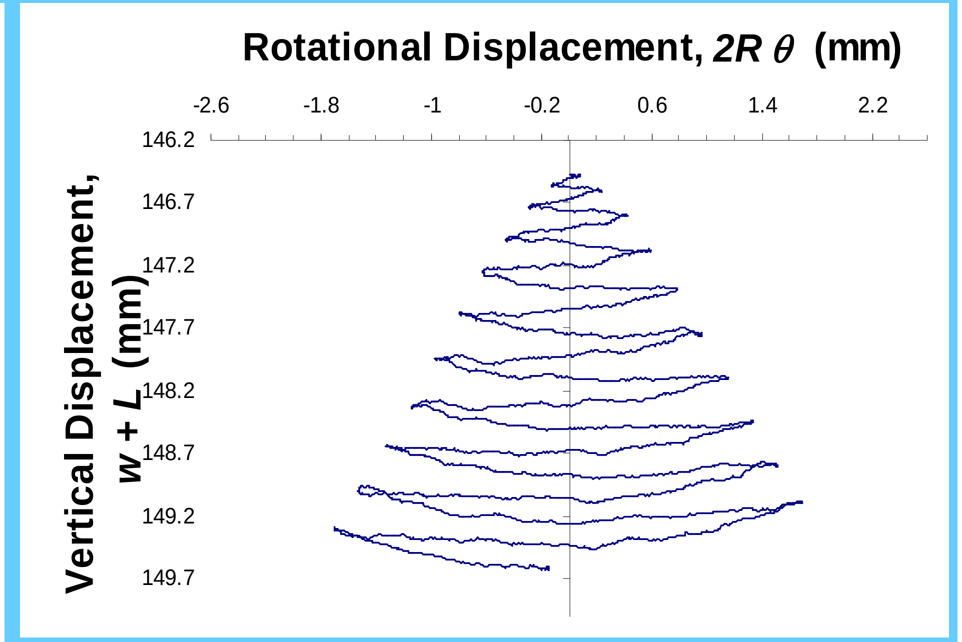
Proof of the Masing rule



Uplift and settlement occurring during cycling

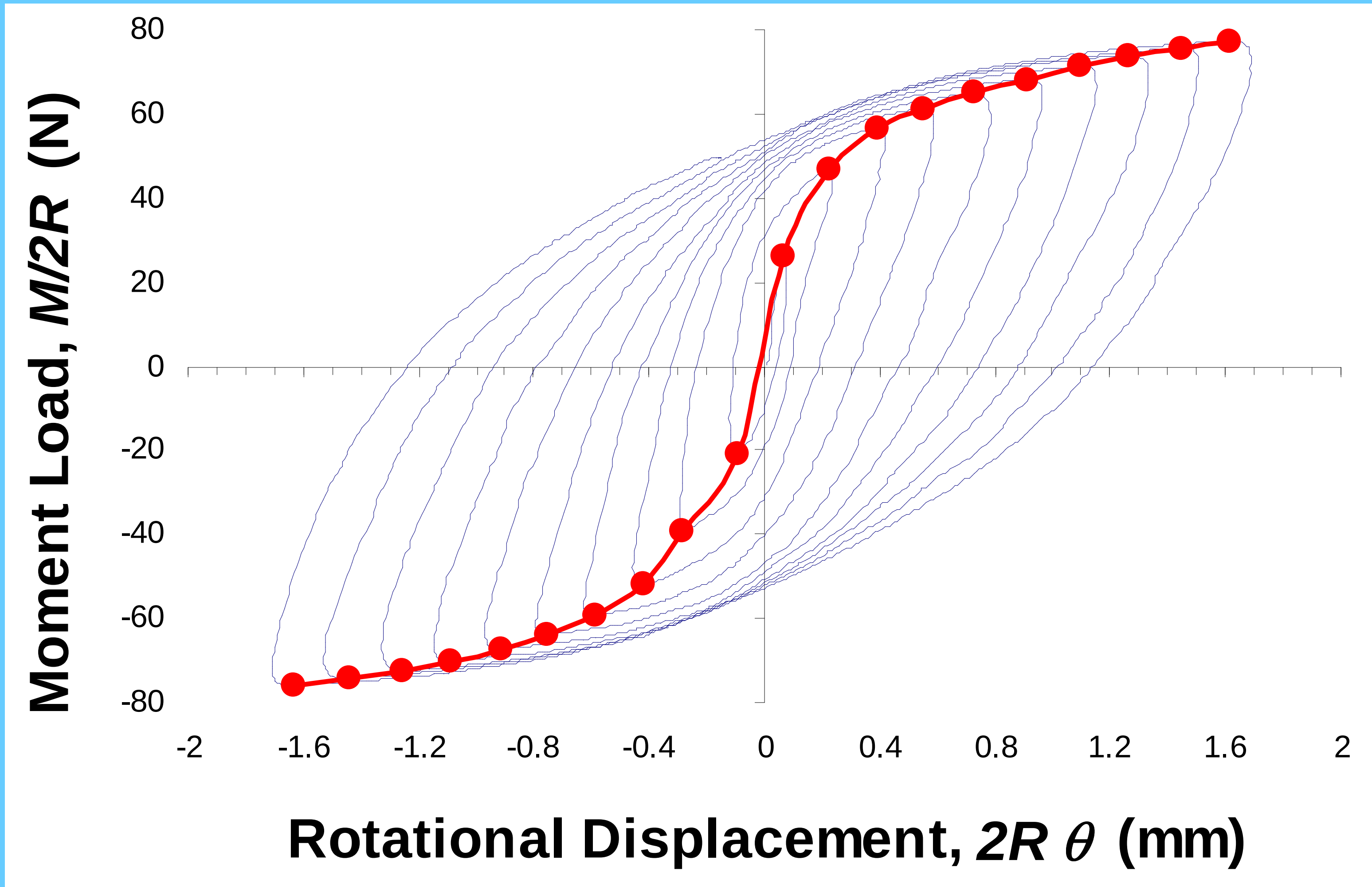


***V* = 50N**

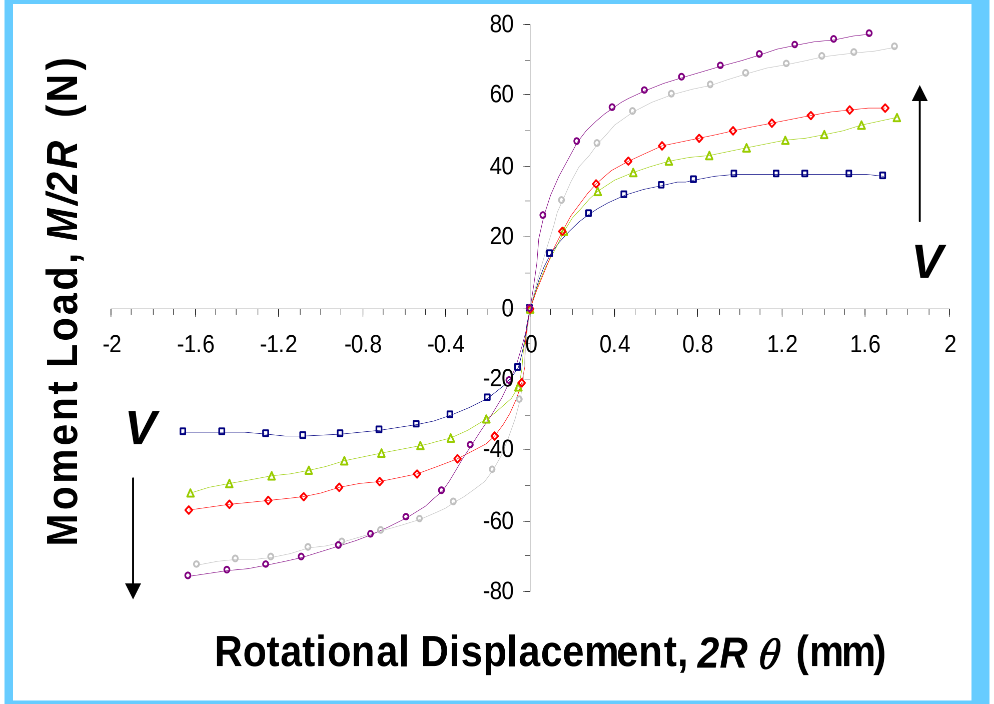


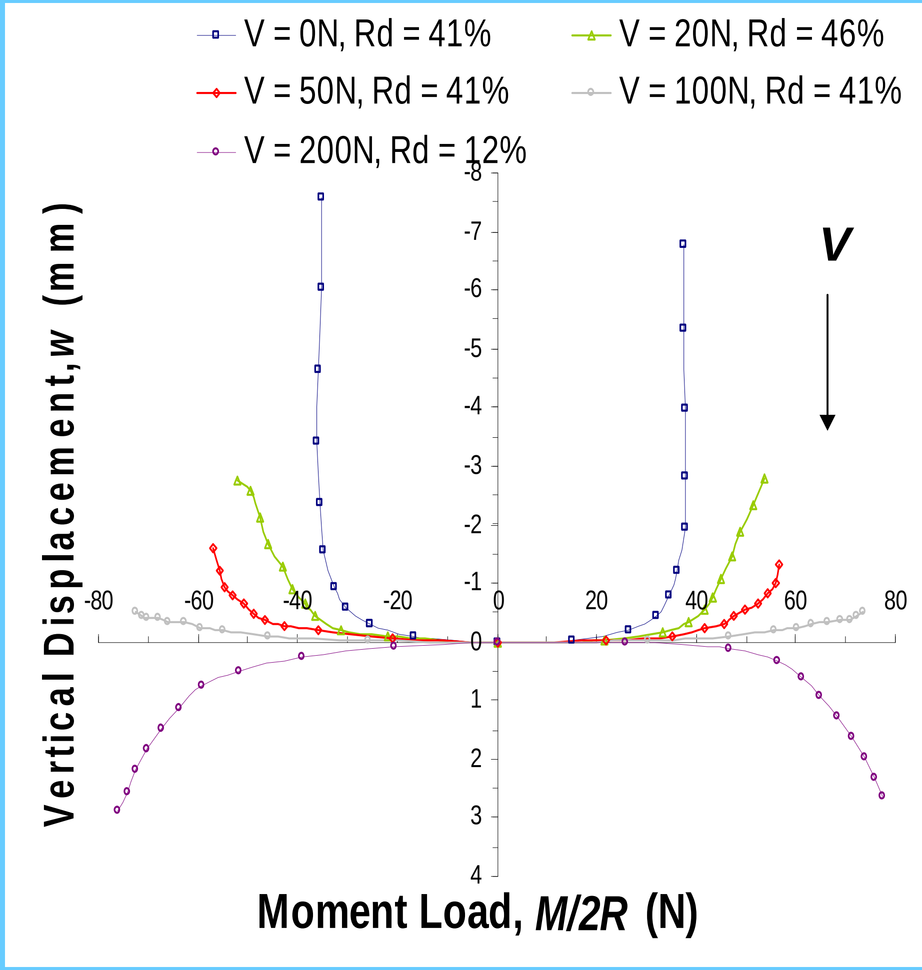
***V* = 200N**

Peaks of moment load – rotational displacement backbone curve



Peaks of load versus displacement: *M/2RH* = 1 and *L/2R* = 0.5





Conclusions

- Beneficial effect in the cyclic response of the caisson when the vertical load increases
- Evidence of uplift if the suction caisson is in a condition of $V < M/2R$ or $V < H$ (for $L/2R = 0.5$)
- Secant stiffness reduces with the amplitude of cycle
- Proof of the Masing rules
- Results to be used in the construction of a continuous hyperplasticity model