Dedicated to innovation in aerospace

NLR contribution to Aeroelastic Prediction Workshop

NLR Team

Outline

Jaap van Muijden
- aerodynamic grid
- CFD simulations

Bart Eussen
- aeroelasticity

Bimo Prananta
- FEM data
- pre-post processing

Introduction
- NLR team
- tools, contribution

Aerodynamic grid
- NLR modified grid

FEM model
- available data
- pre-processing

Results
- HIRENASD

NLR tools and contributions

ENFLOW CFD system

- components: ENDOMO domain modeller, ENGRID grid generator, ENSOLV flow solver
- structured multiblock grids, 2^{nd} of 4^{th} accurate space discretisation, 2^{nd} order dual-time stepping, multigrid acceleration

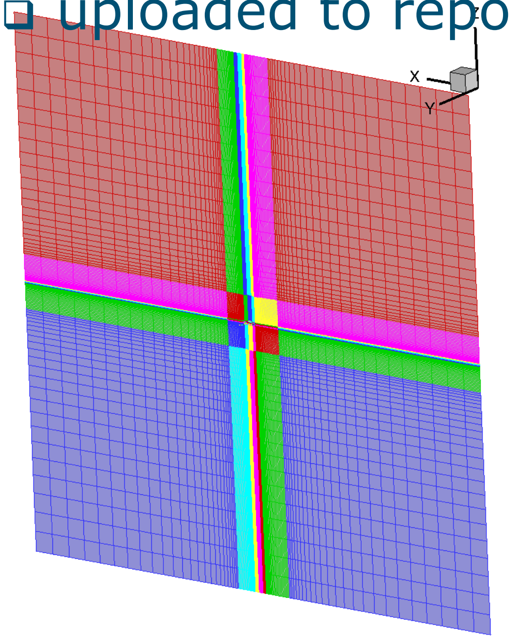
NLR contributions

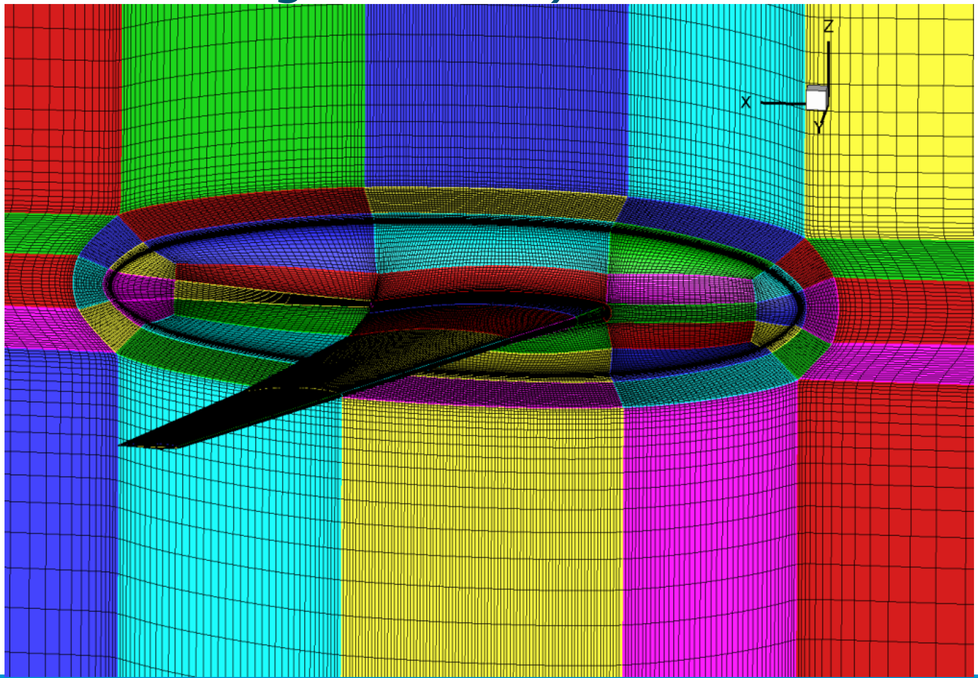
- forced oscillation of 2^{nd} mode, 4 periods, 32 time-steps/cycle; starting from statically deformed grid
- using AePW specified amplitudes, dynamic pressure derived from q/E data
- solver setting: 2^{nd} order space and 2^{nd} order time integration, 60 multigrid (4W)
- k-ω TNT (turbulent-non-turbulent) + EARSM (explicit algebraic Reynolds Stress Model)

Aerodynamic grid

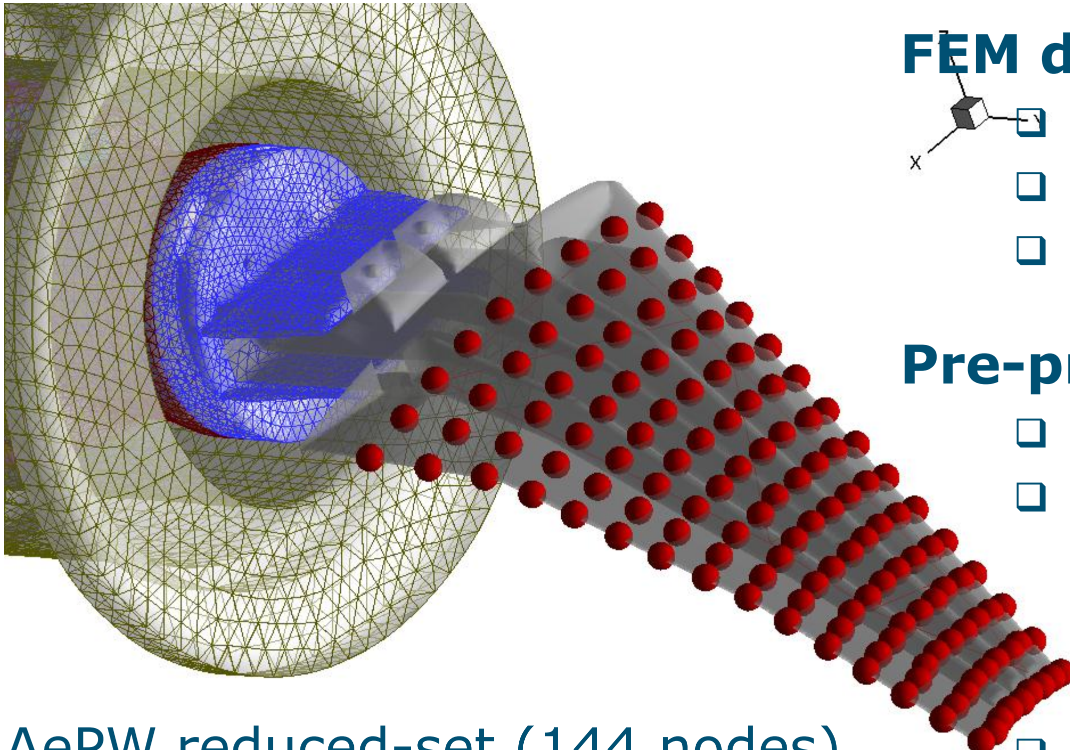
NLR grid

- started from ICEM topology available on repository
- modifications:
  - blocks subdivided for improved parallelisation (now 352 blocks)
  - blocks rearranged for improved boundary layer resolution
  - block dimensions set suitable for NLR multigrid acceleration (now 9,632,768 cells and 4 multigrid levels)
- uploaded to repository





FEM model and pre-processing steps



AePW reduced-set (144 nodes)

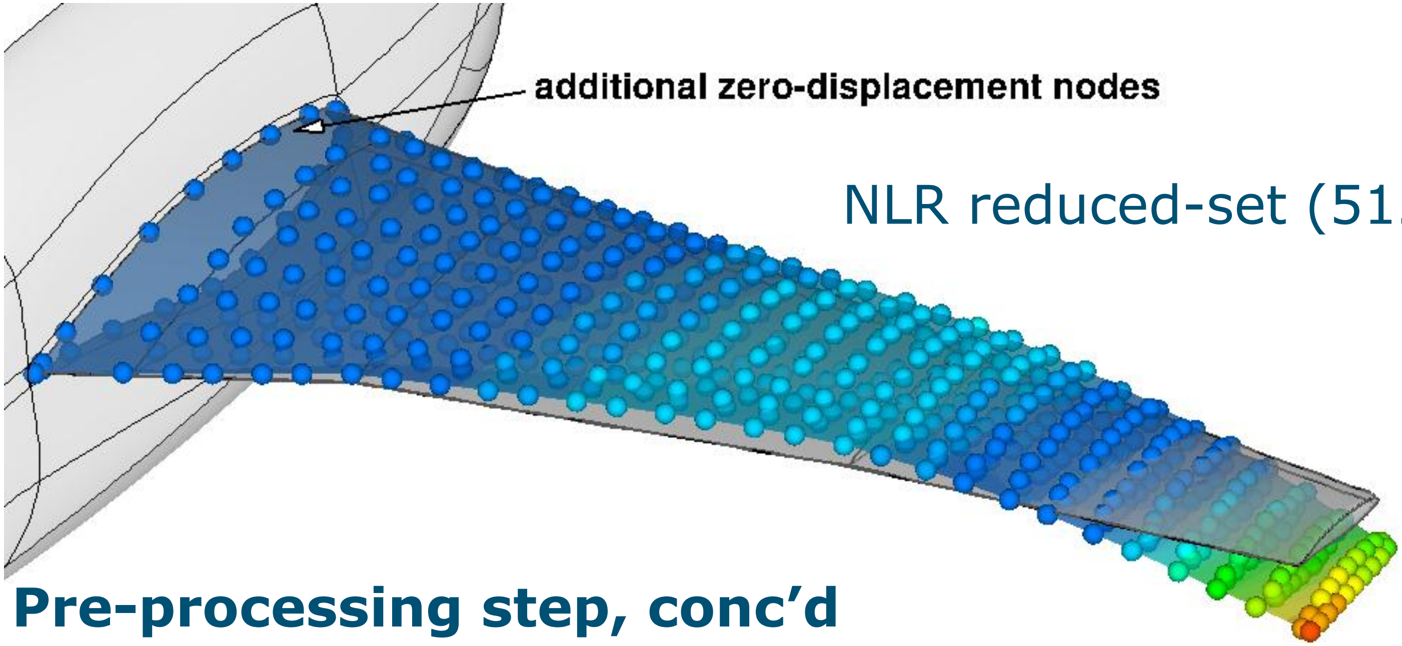
FEM data in repository

- NASTRAN source (bdf)
- g-set modal data (f06)
- reduced-set modal data (f06)

Pre-processing steps

- rerun the bdf, for check
- select different reduced-set, since the available data not enough for volume spline
- generate FLEX matrix for NLR reduced-set for static-aeroelastic runs; using SOL101 with unit loads

FEM model and pre-processing steps, conc'd

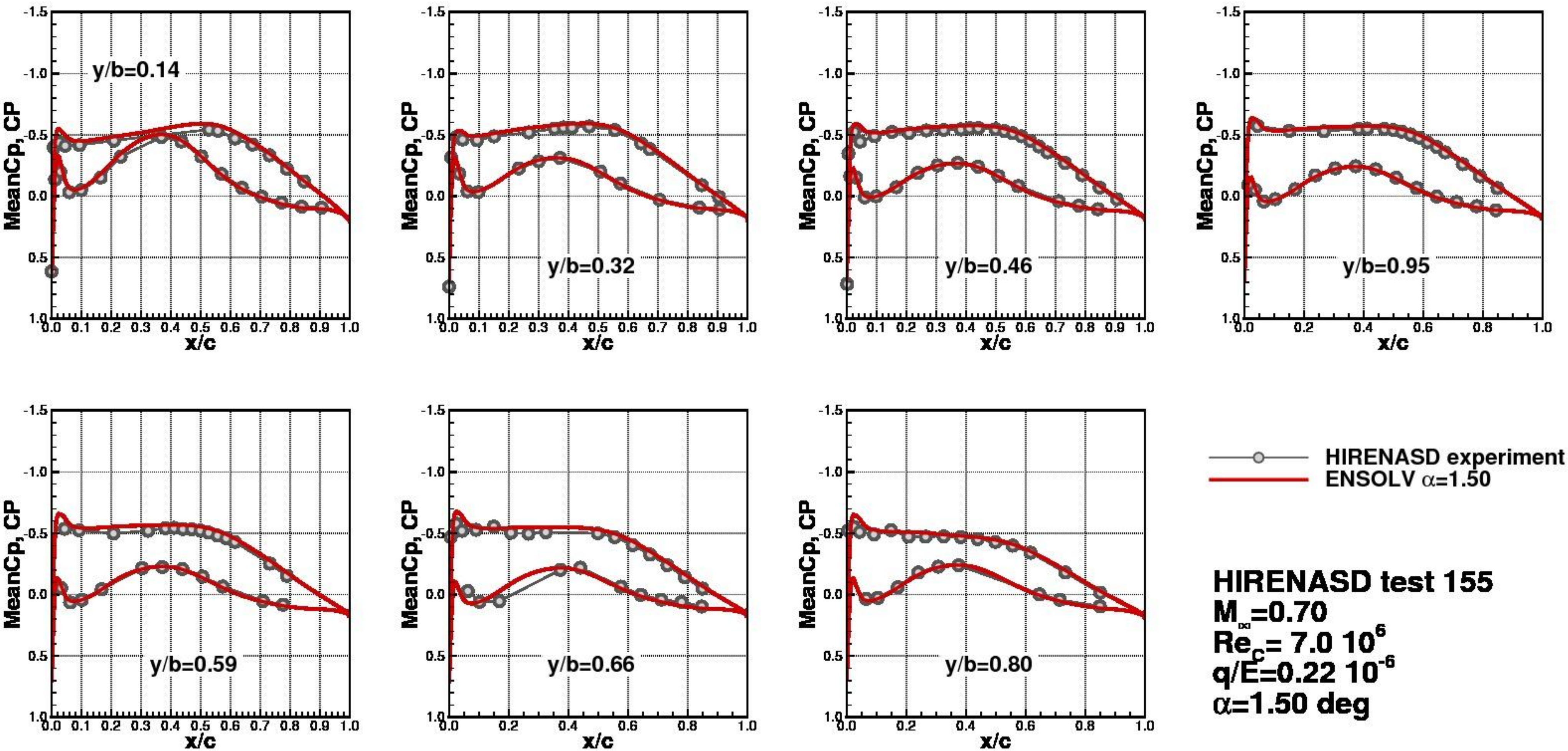


NLR reduced-set (512 nodes)

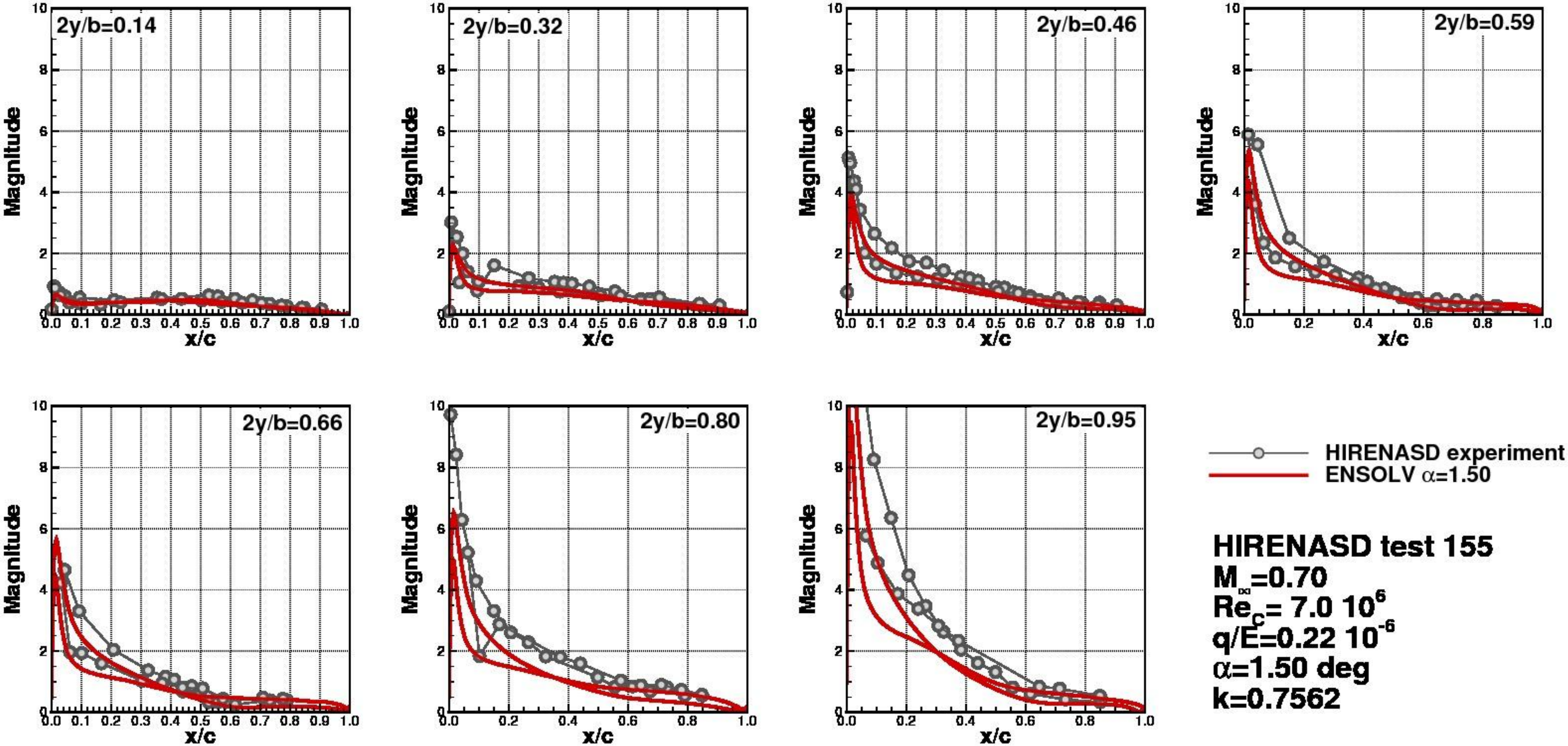
Pre-processing step, conc'd

- extract mode shape data for NLR reduced-set from AePW g-set modal data (f06), consists of upper and lower surface nodes
- introduce zero displacement nodes at wing-body junction
- map mode shape data to aerodynamic surface grid (volume spline)

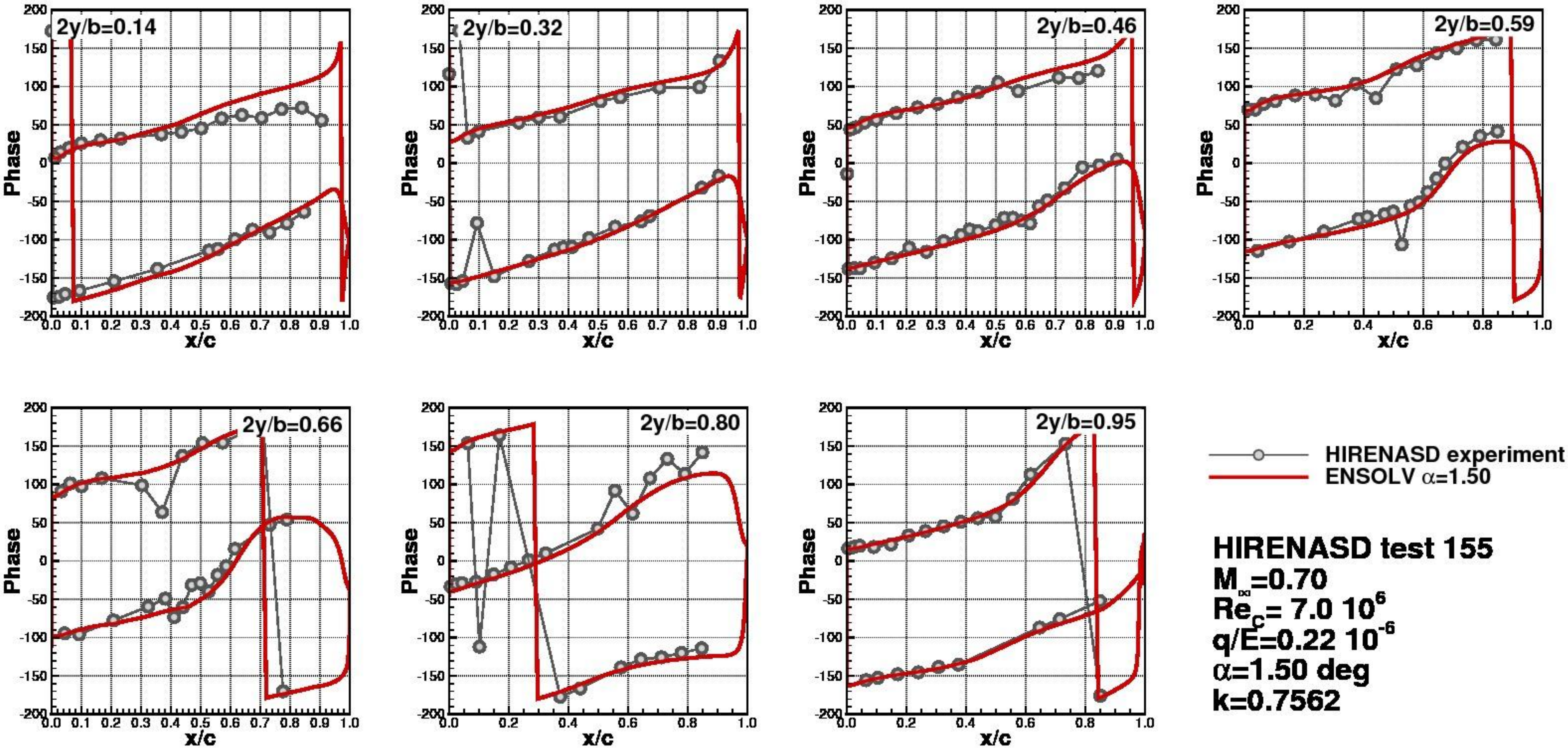
Test 155, steady



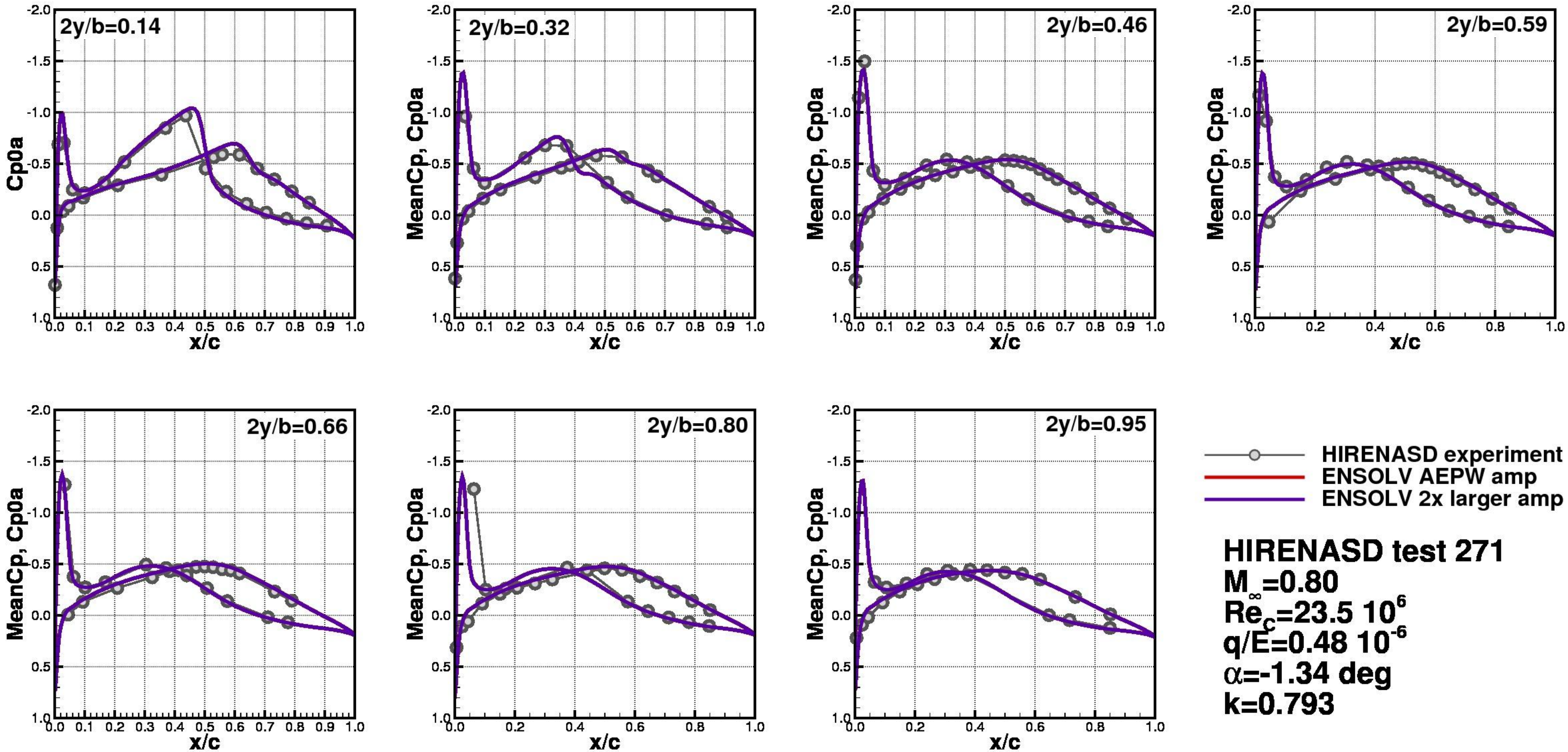
Test 155, magnitude



Test 155, phase angle

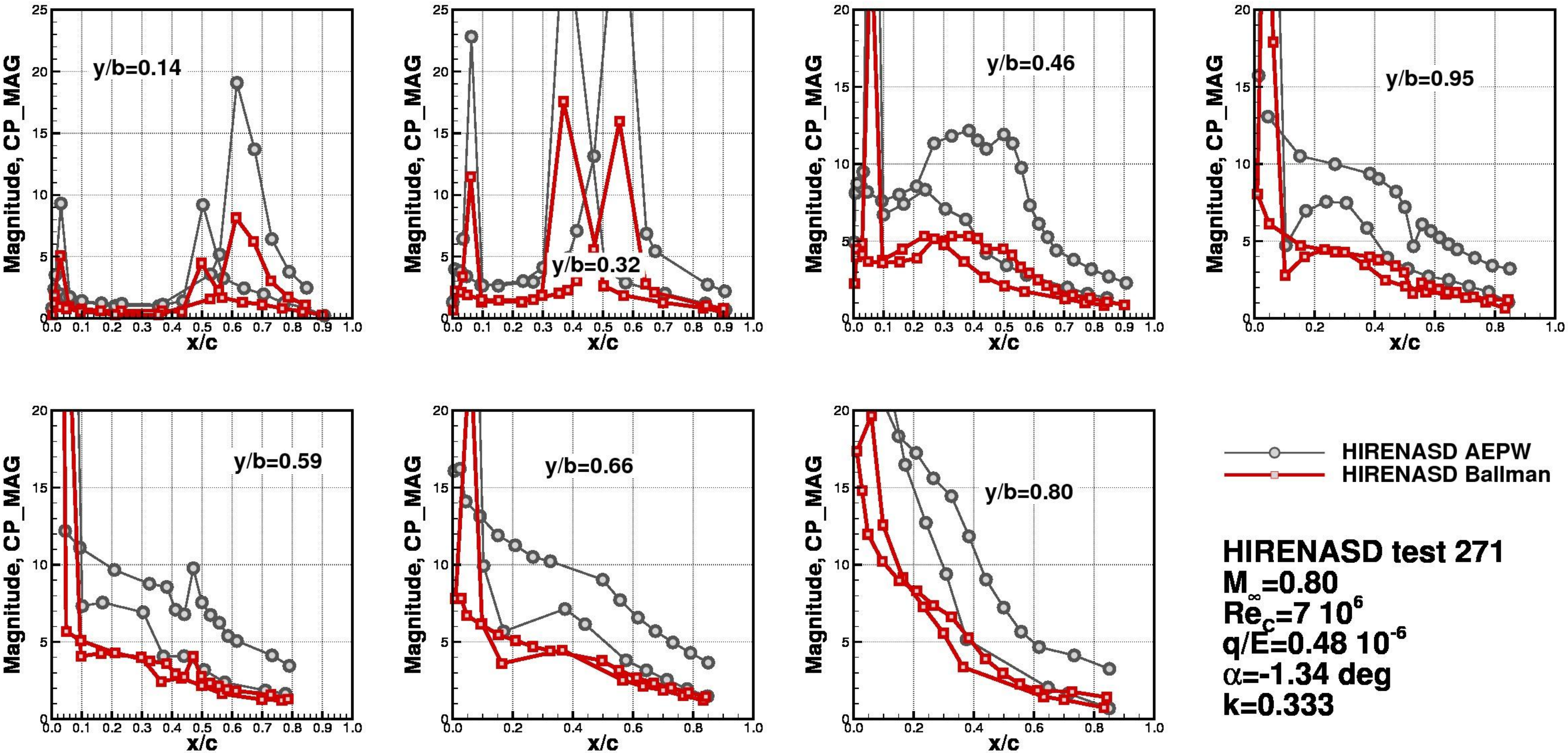


Test 271 steady, low C_L

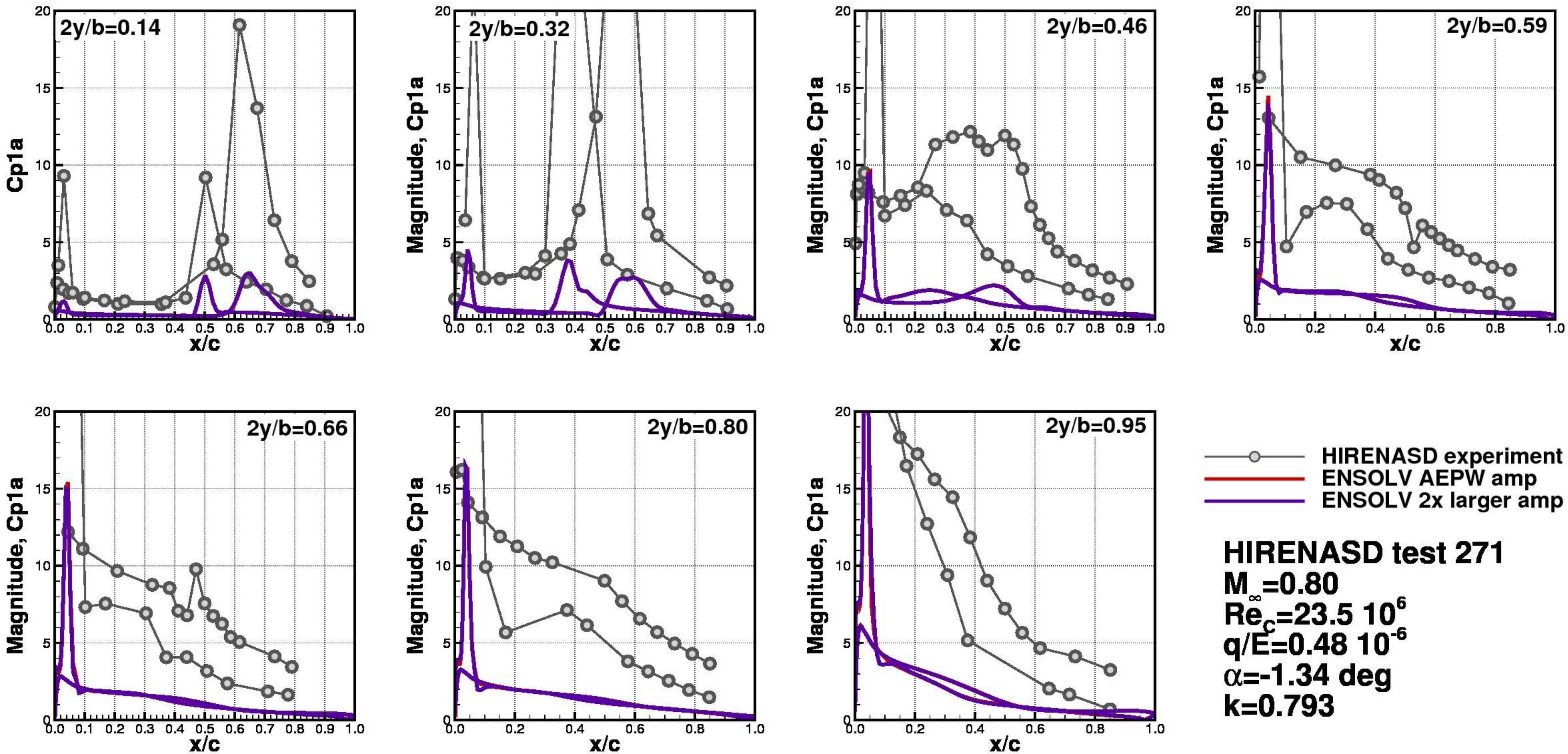


HIRENASD test 271
M_∞=0.80
Re_c=23.5 10^6
q/E=0.48 10^{-6}
α=-1.34 deg
k=0.793

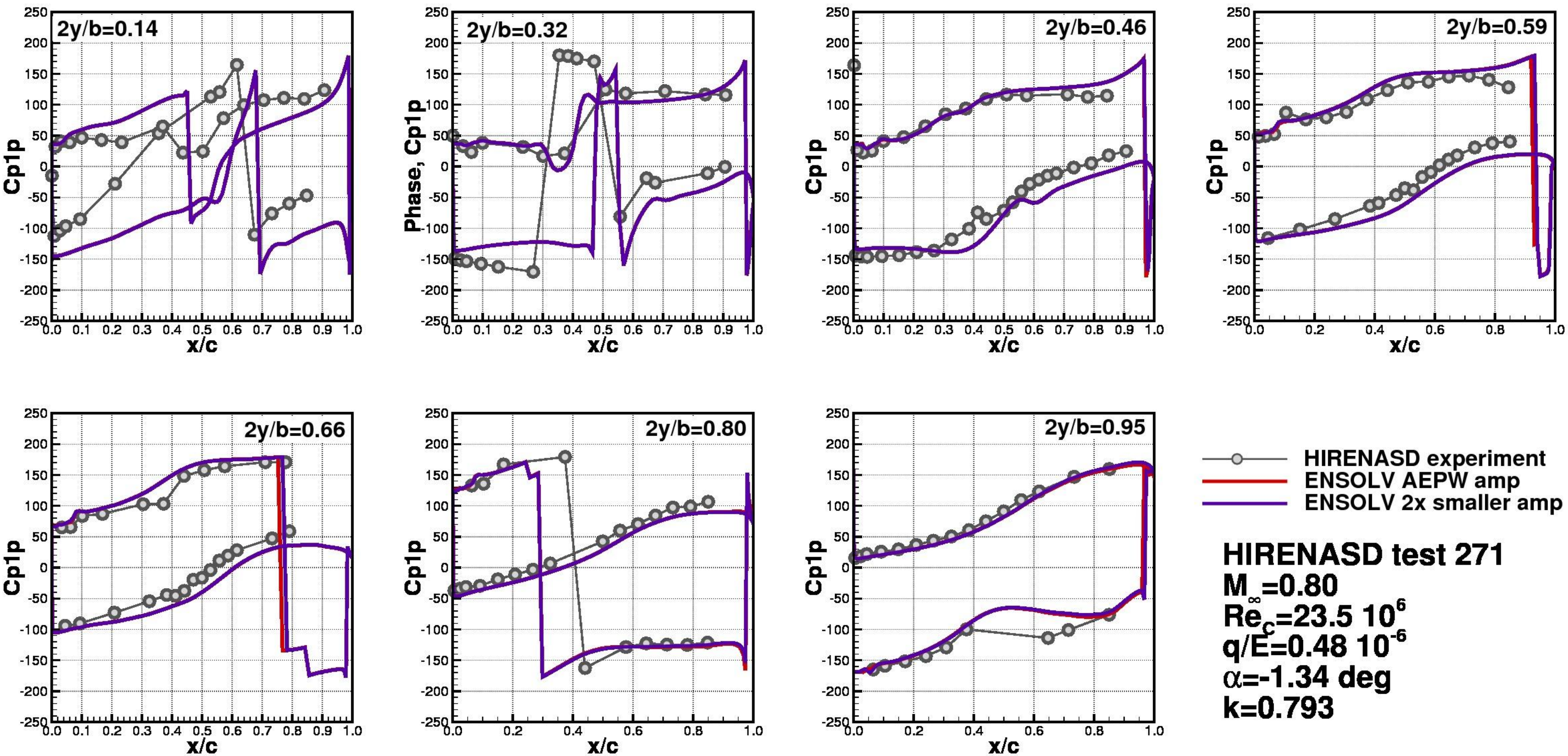
Experimental data Test 271, magnitude AePW vs RWTH



Test 271 magnitude

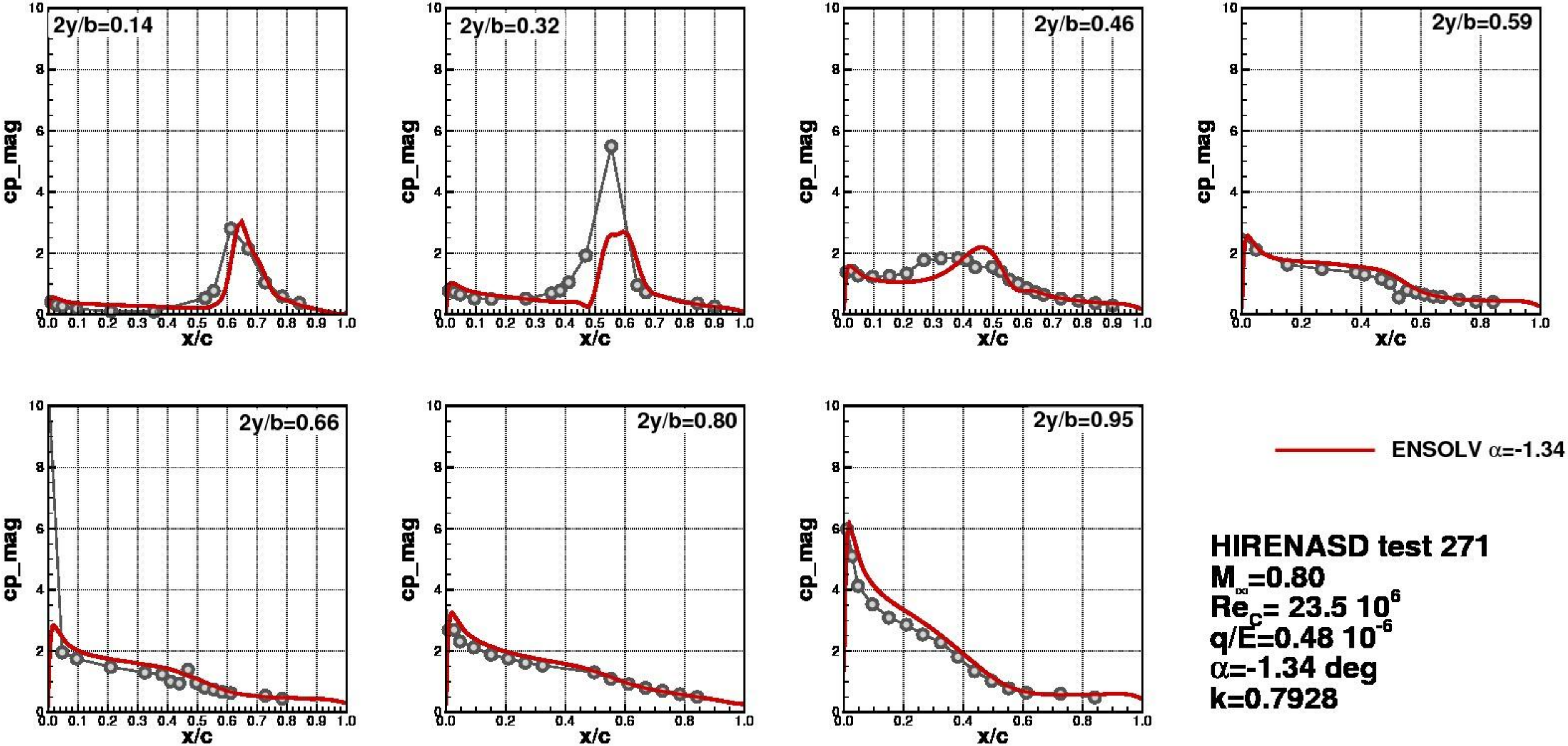


Test 271, phase angle

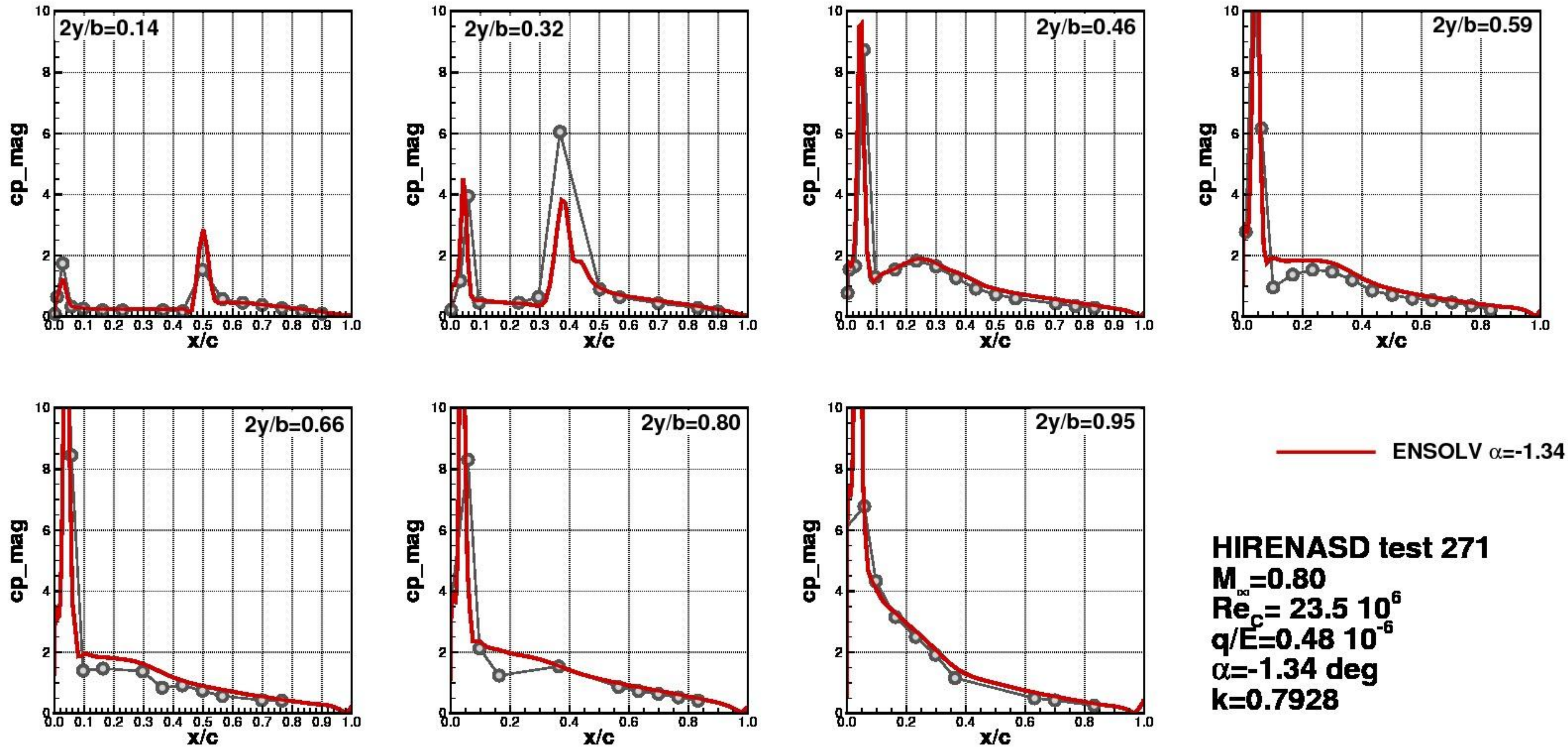


HIRENASD test 271
M_∞=0.80
Re_c=23.5 10^6
q/E=0.48 10^{-6}
α=-1.34 deg
k=0.793

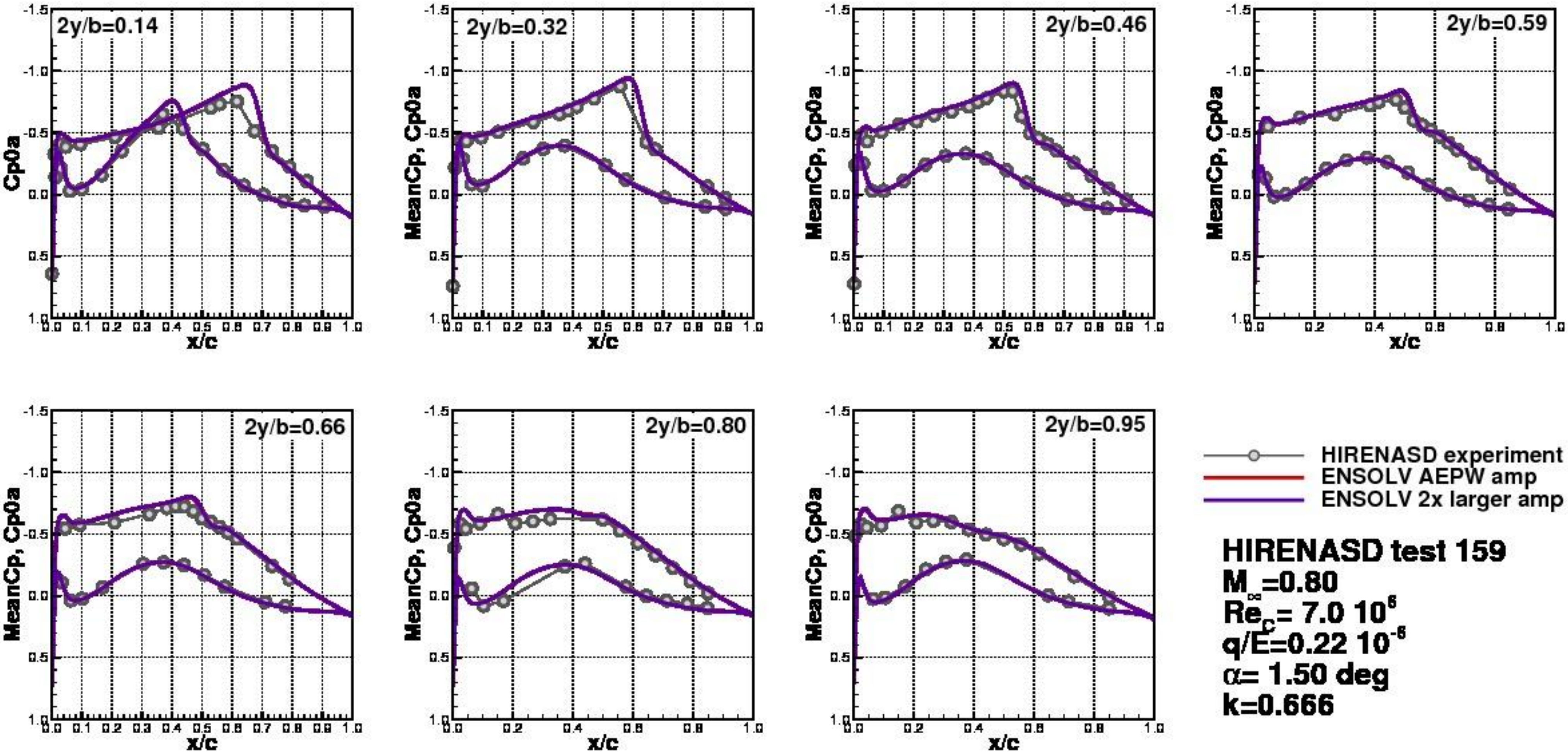
Test 271 magnitude upper surface RWTH experimental data



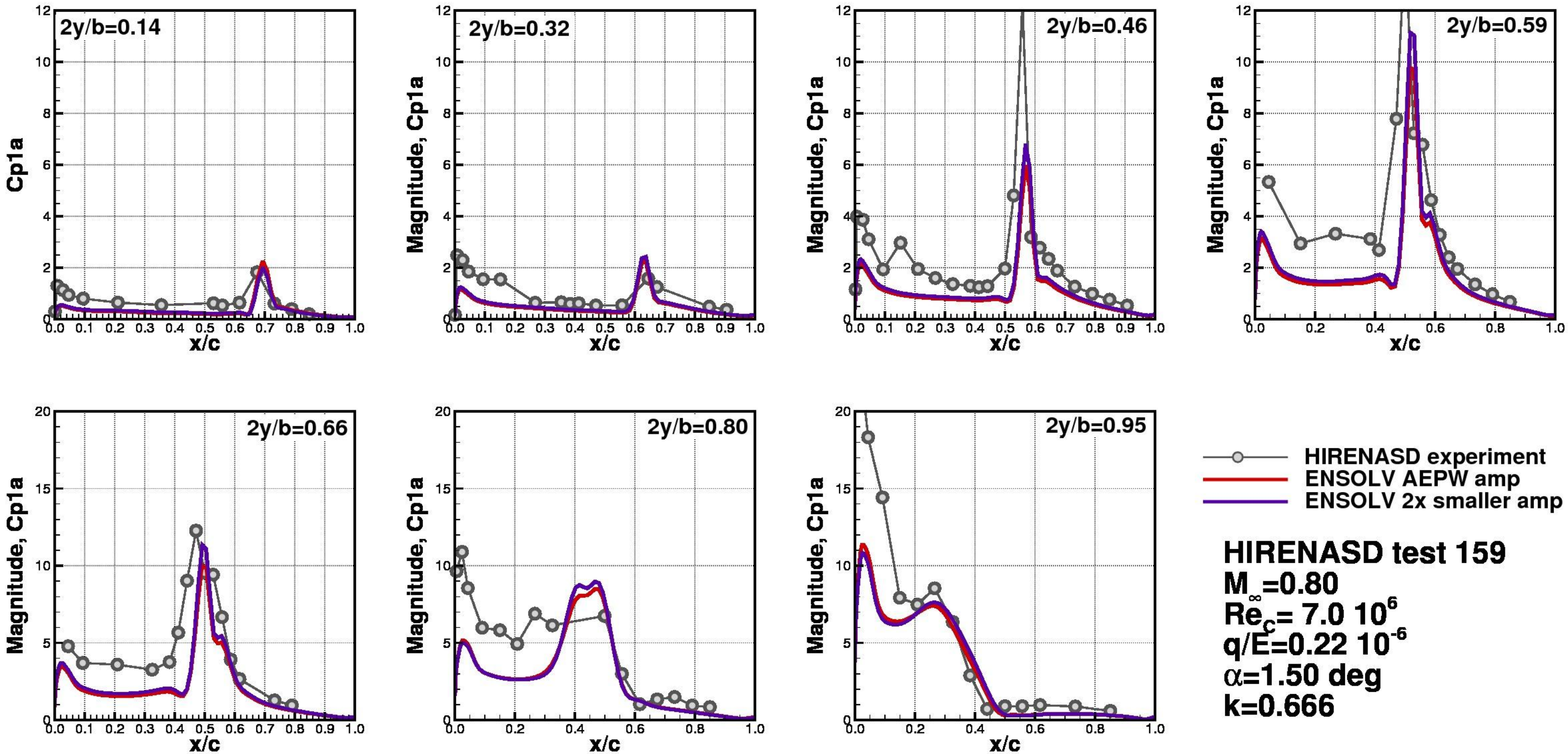
Test 271 magnitude lower surface RWTH experimental data



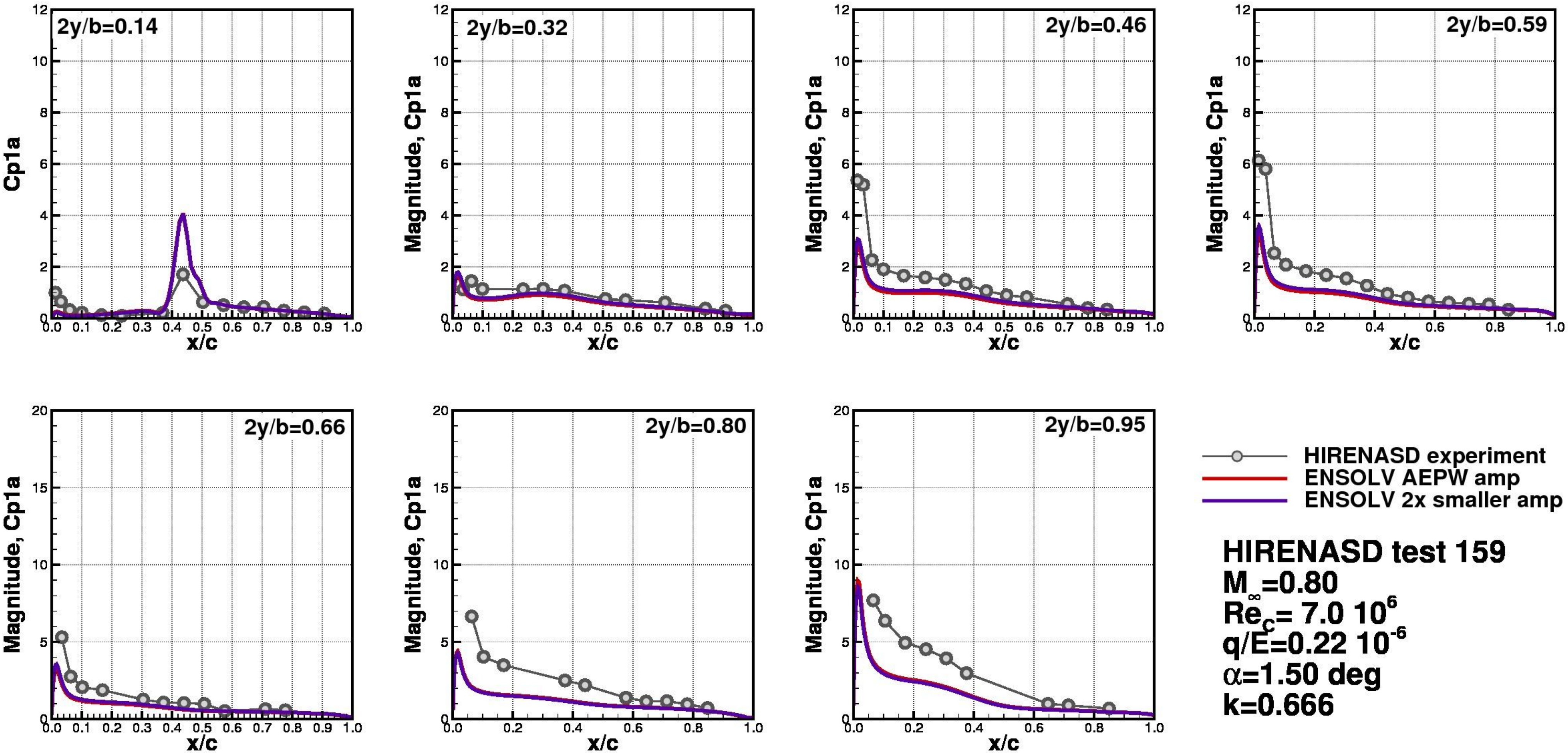
Test 159, steady high C_L



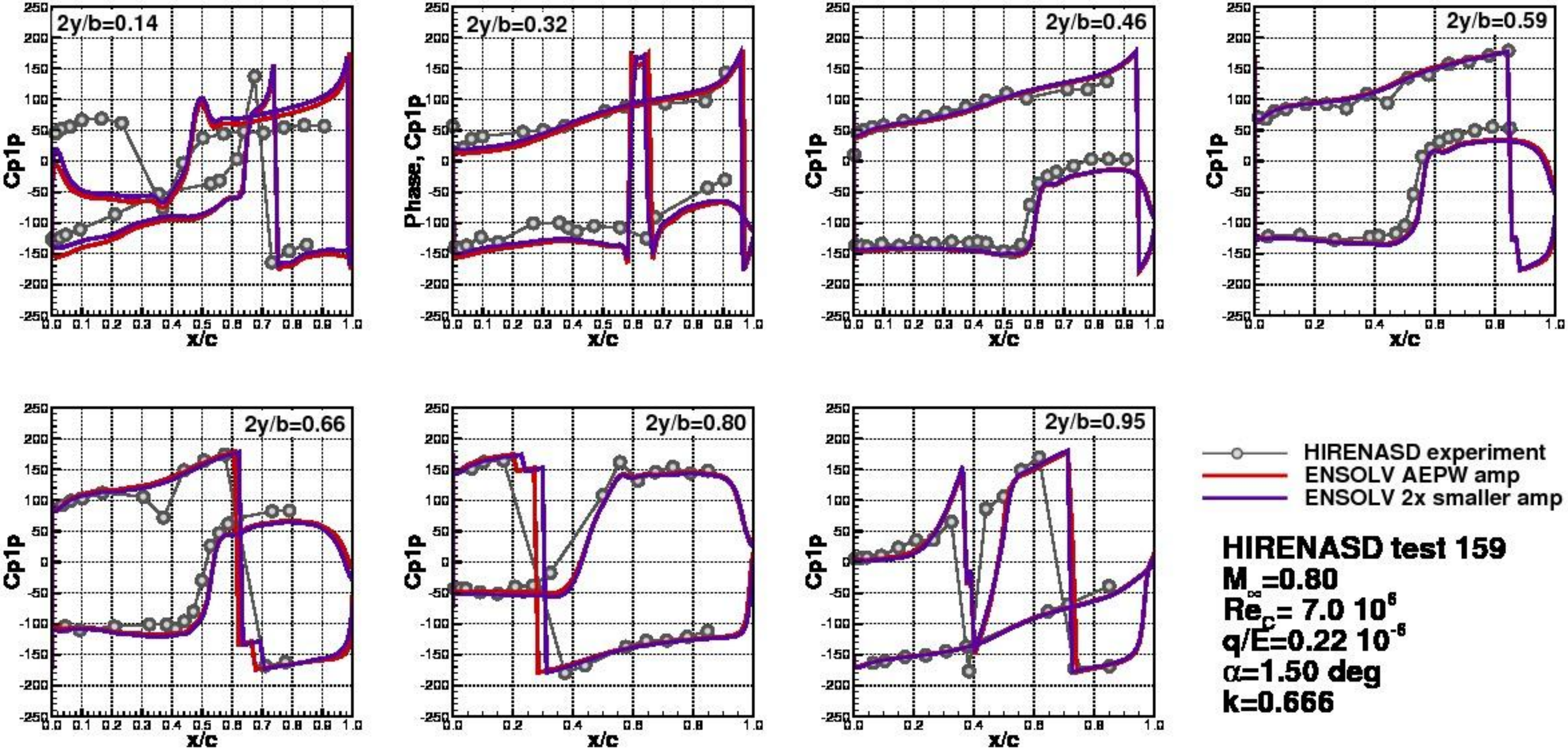
Test 159, magnitude upper-side



Test 159, magnitude lower-side



Test 159, phase angle



HIRENASD test 159
M_∞=0.80
Re_c= 7.0 10^6
q/E=0.22 10^{-6}
α=1.50 deg
k=0.666

Remarks

- nice test case, frequency relatively high
- amplitude variation shows linear behaviour

- NLR optimised the presented structured multiblock grid
- to use the same FEM for all cases, dynamic pressure derived from q/E values. NLR used the E value of wing part (material ID 58).
- q/E influences static deformation as well as dynamic pressure. should be explicitly defined?
- remaining uncertainties w.r.t. test 271 data; derived from identical time-trace?

- compared using TECPLOT; why not submission in TECPLOT format?

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