Budapest University of Technology and Economics
Department of Structural Engineering

Optimal stiffener geometry based on nonlinear analysis of longitudinally stiffened plates under compression

József Simon

Supervisor
Dr. Vigh László Gergely

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Earthquake analysis of bridges in moderate seismic zones

In Hungary there is no tradition of seismic design

Hungary has been classified into moderate seismic zones

Damage can be significant

EUROCODE 8 : seismic safety check has to be done

Earthquake analysis of bridges in moderate seismic zones

1. Analysis of extant bridges

- Database about extant bridges
- Representative structures
- Numerical analysis (spectral and time-history)
- Critical structural types and details
- Damage prediction

↓

Alternative reinforcing/retrofit methods

2. New design conceptions

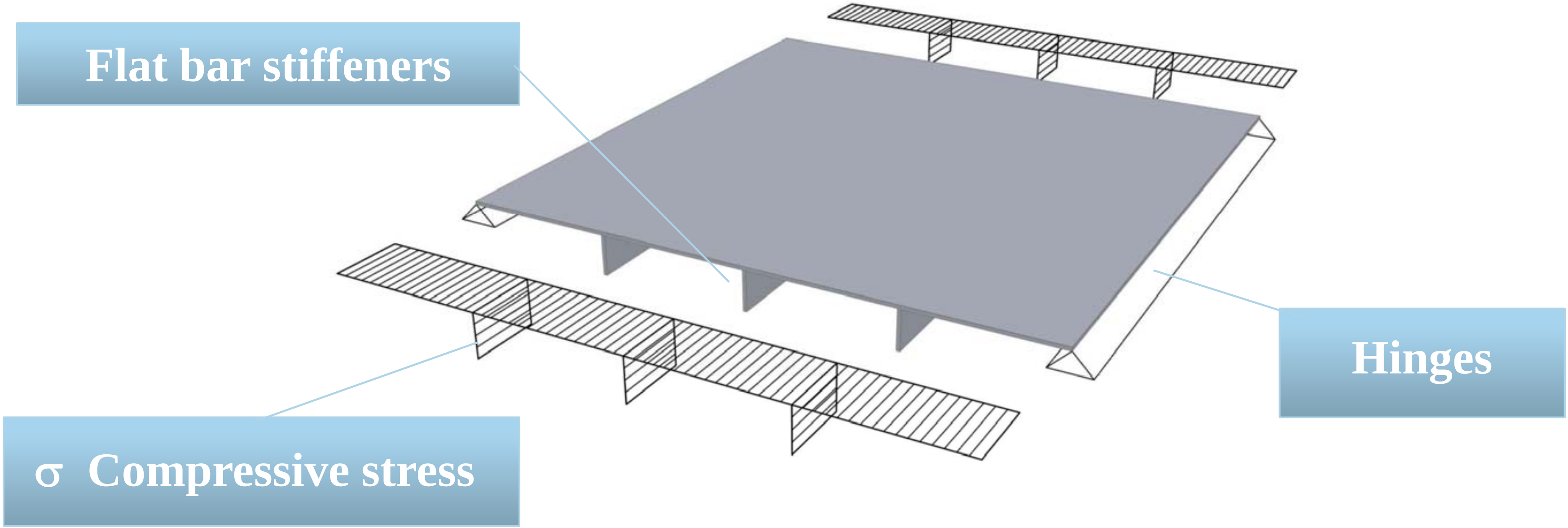
Stiffened plates

Thin-walled structures — Ultimate load/Material consumption
Stability failure is dominant

Ultimate load, failure — Stiffness ratios

Aim of the studies

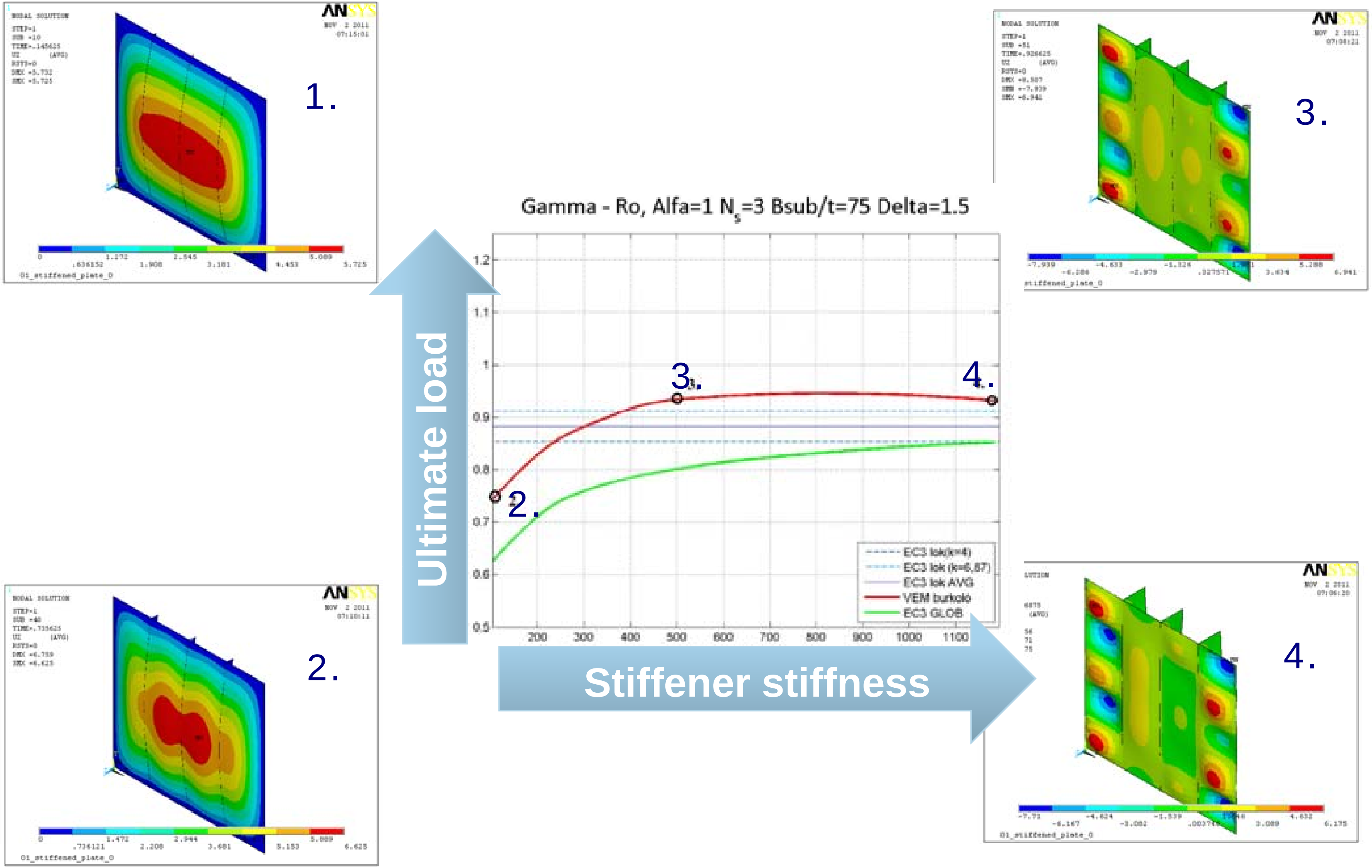
Longitudinally stiffened plate, pure compression.



Parameters characterizing the stiffeness relations :

$$\gamma = \frac{EI_y}{D_p b}; \qquad \delta = \frac{A_x}{b t_p}; \qquad D_p = \frac{E t_p^3}{12(1-\nu^2)};$$

Optimal stiffener geometry



Methods to calculate the optimal relative stiffness

By elastic critical stress

- $$\gamma_c^* = \frac{1}{n_s + 1}\left[\frac{\alpha^2}{m_{ov}}\left(4(n_s + 1)^2\big(1 + \delta(n_s + 1)\big) - 2 - \frac{\alpha^2}{m_{ov}}\right) - 1\right]$$
- Perfect geometry, linear elastic material
- Not applicable directly for design

By ultimate loads $\Rightarrow$ GMNI analysis

- Post-critical load bearing capacity
- Imperfections, non-linear, plastic material model
- Can be used for design directly

ULS according to EC3-1-5

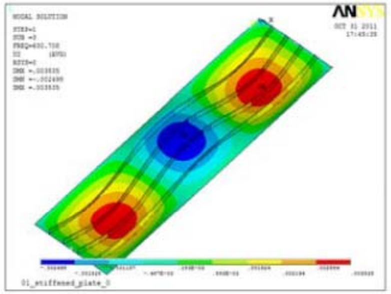
Effecive cross-section method

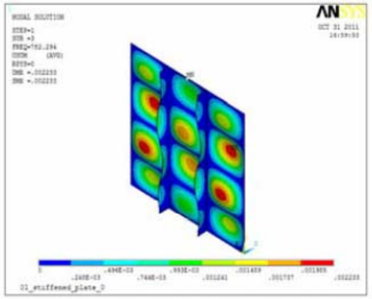
It takes into account the buckling of the elements and their interactions.

Stability failures according to EC3-1-5

Local	Global	Stiffener
• Buckling of subpanels between the stiffeners	• Plate type behaviour • Coloumn type buckling behaviour • Interaction	• Distortional buckling • Minimum geometric requirements • Should be avoided!

Numerical model

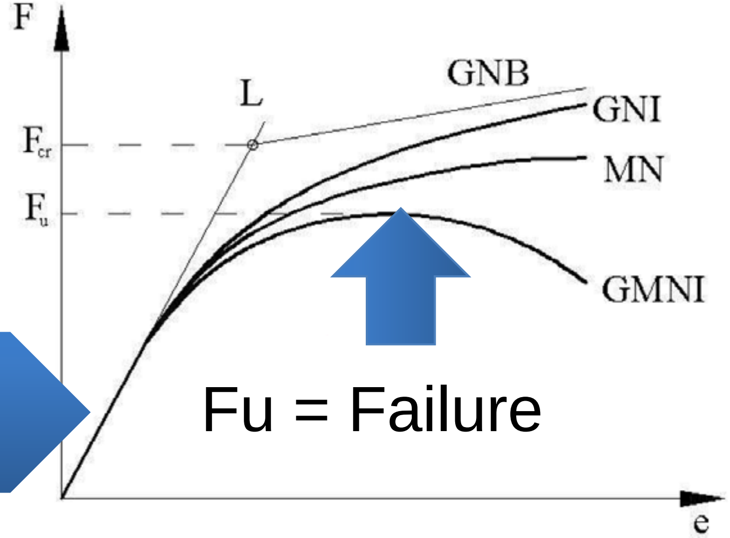


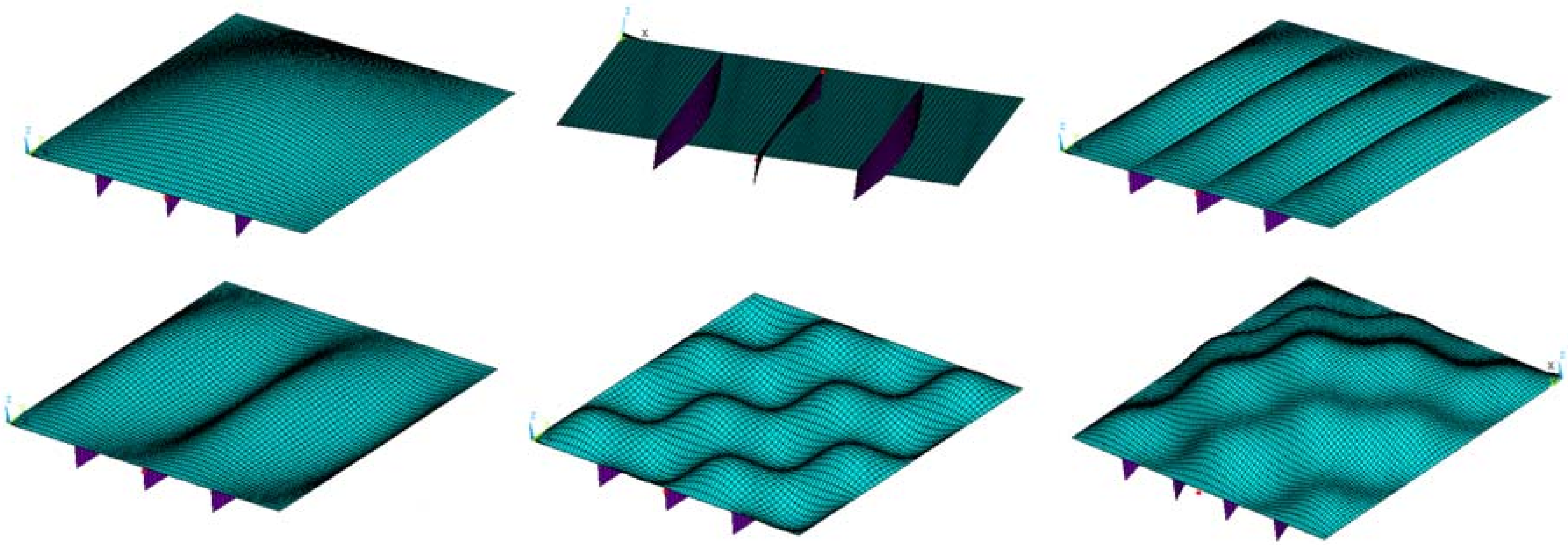


Imperfect geometry
GNI

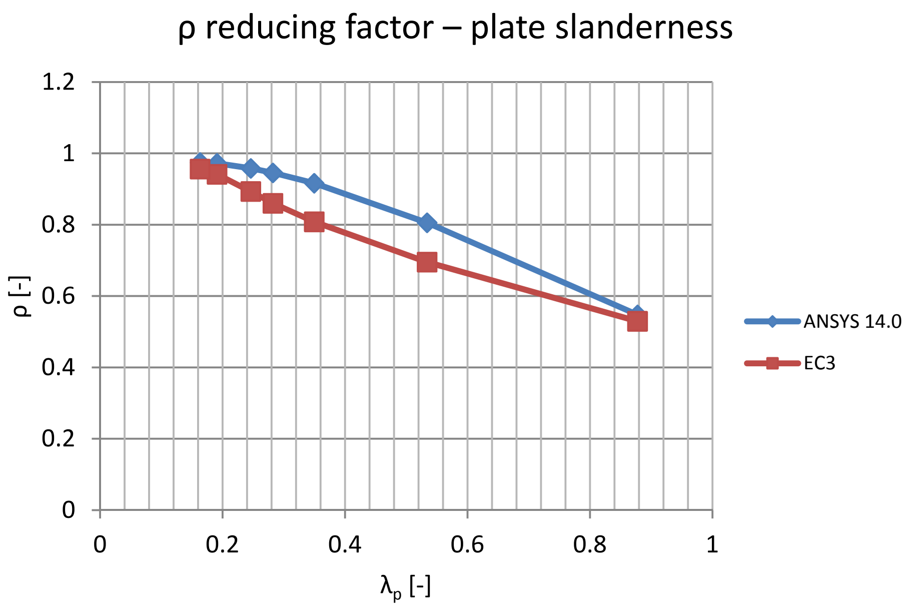
Plastic material behaviour
MN

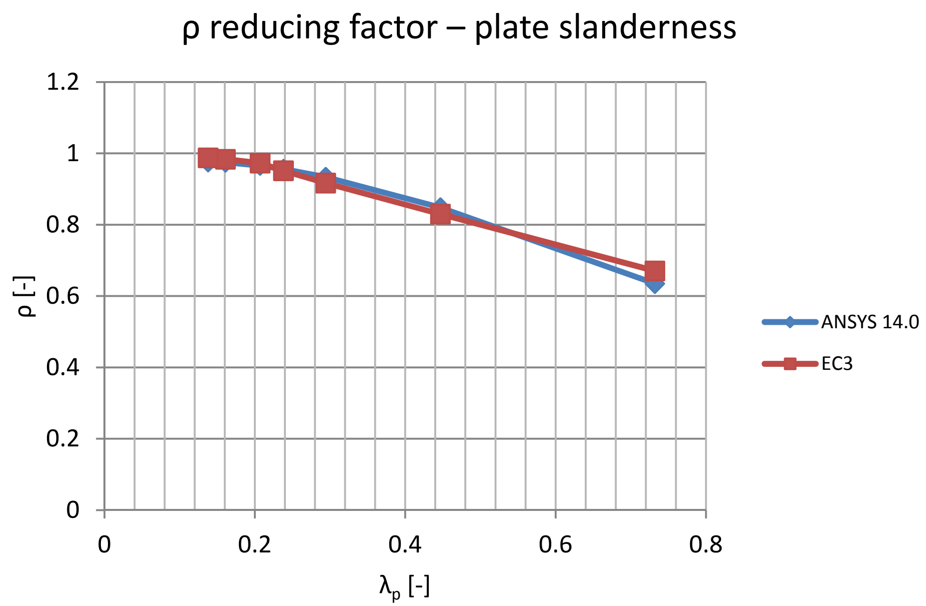
GMNI Analysis

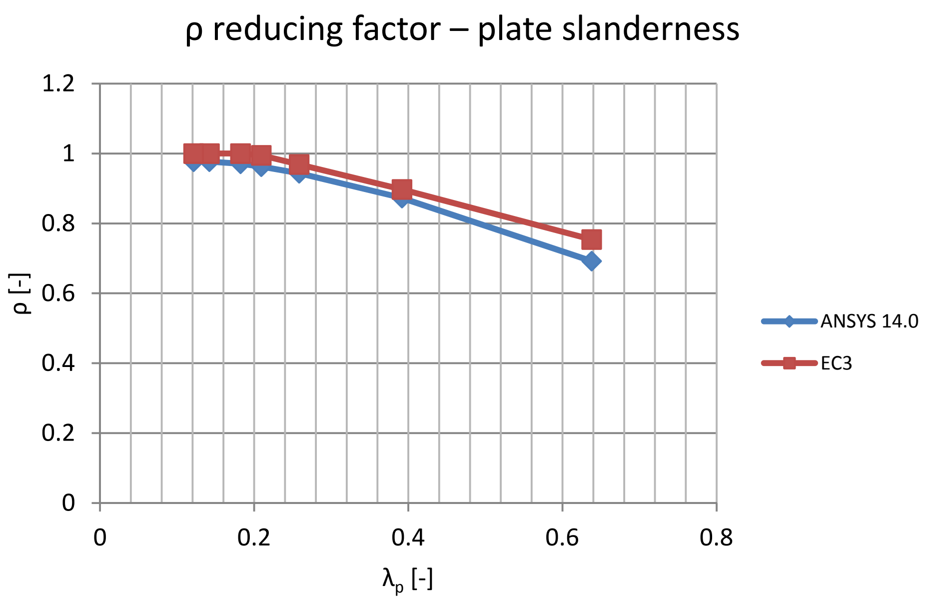


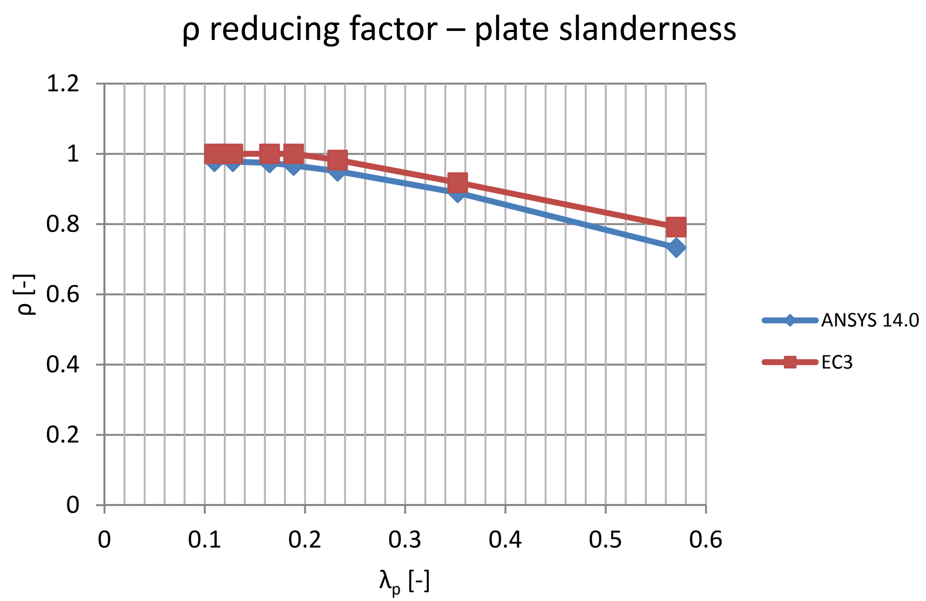


Results 1


ρ reducing factor – plate slanderness
ρ [-]
λp [-]
ANSYS 14.0
EC3

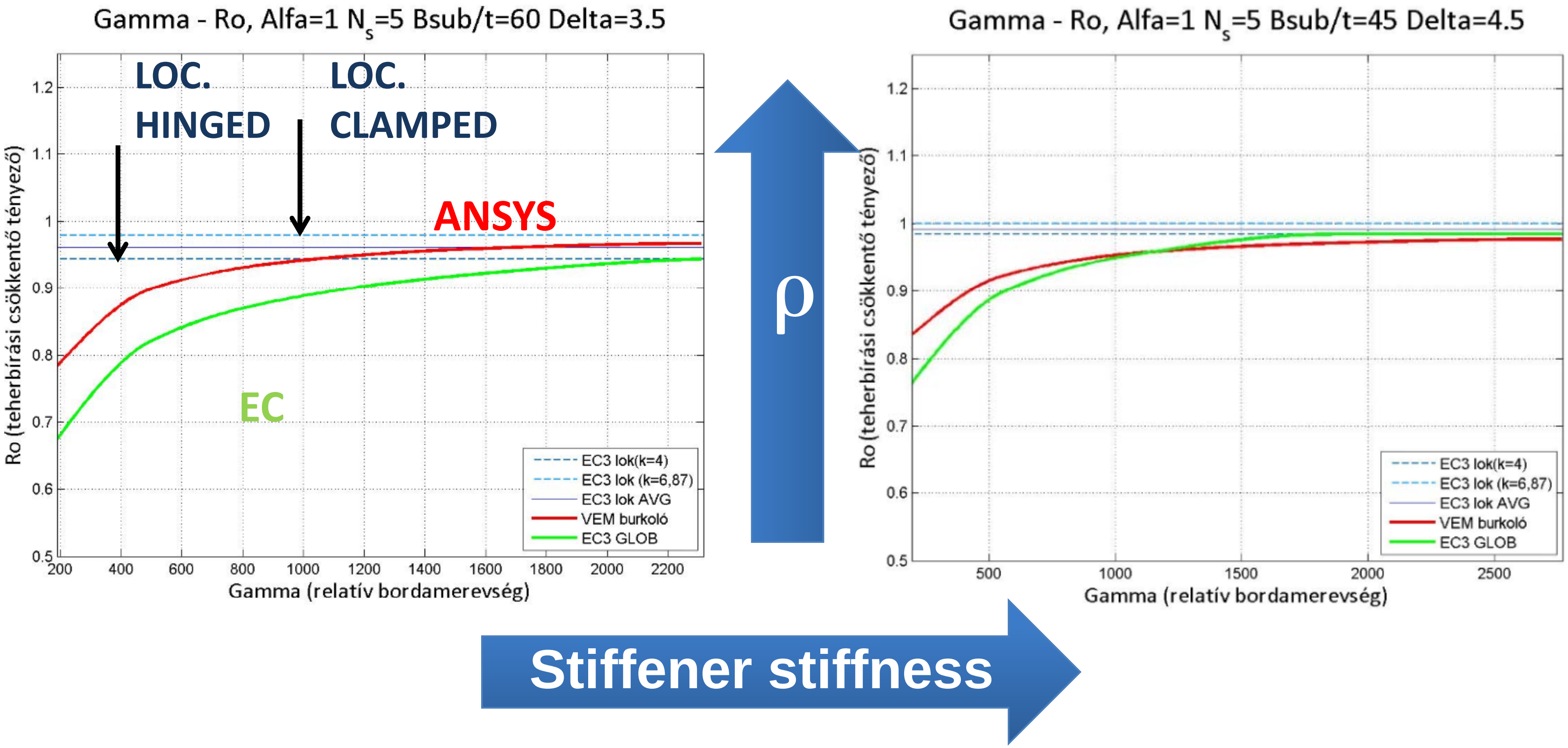

ρ reducing factor – plate slanderness
ρ [-]
λp [-]
ANSYS 14.0
EC3


ρ reducing factor – plate slanderness
ρ [-]
λp [-]
ANSYS 14.0
EC3

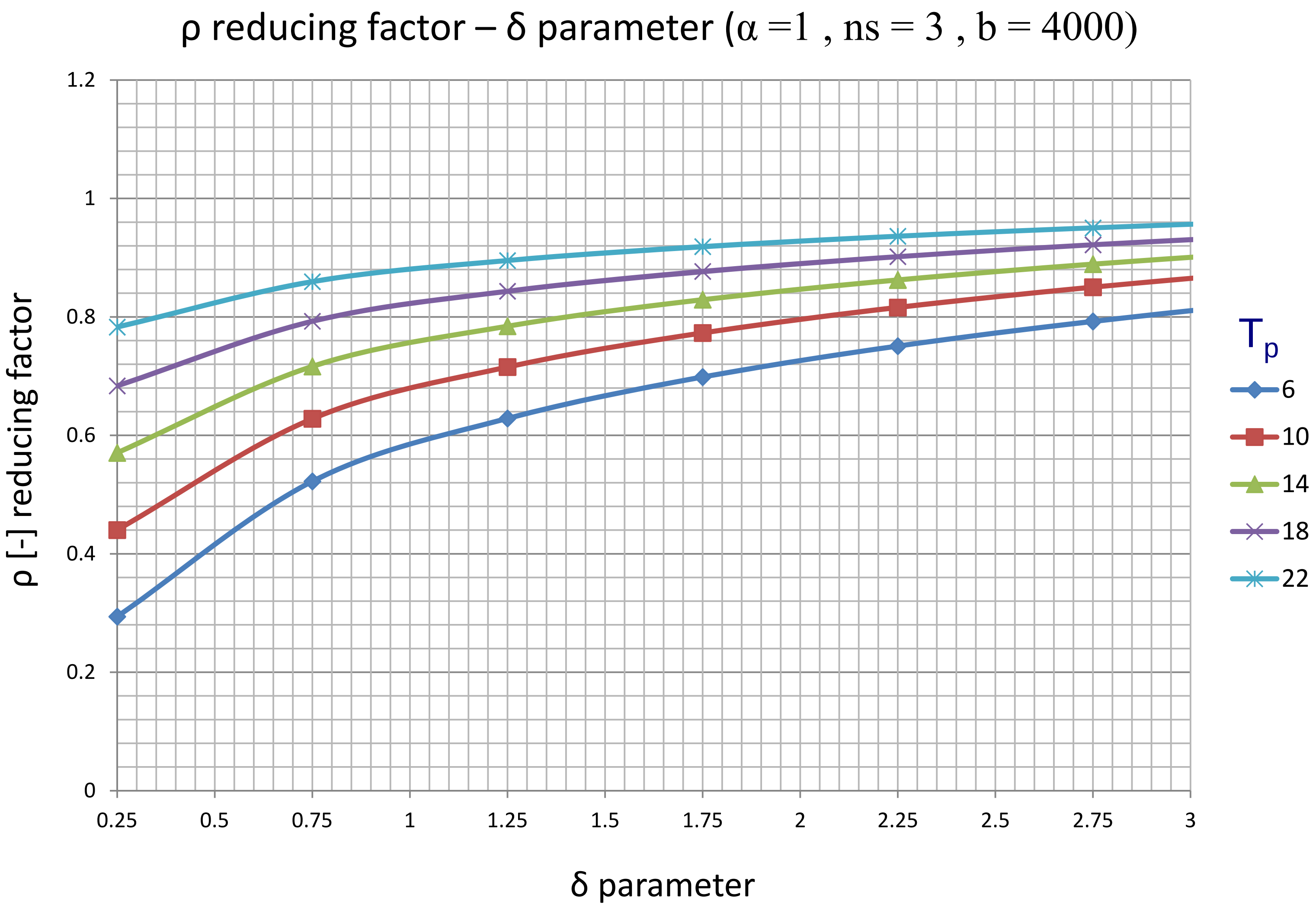

ρ reducing factor – plate slanderness
ρ [-]
λp [-]
ANSYS 14.0
EC3

Results 2

Plates with higher and lower slanderness



Results 3


ρ reducing factor – δ parameter (α =1 , ns = 3 , b = 4000)
ρ [-] reducing factor
δ parameter
1.2
1
0.8
0.6
0.4
0.2
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
2.25
2.5
2.75
3
T_p
6
10
14
18
22

Thank you for your attention!

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