PULTRUDED PROFILES SECTION RESISTANCE UNDER AXIAL COMPRESSION

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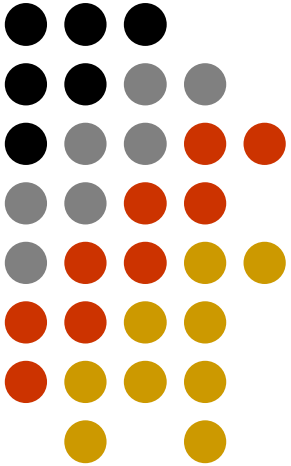
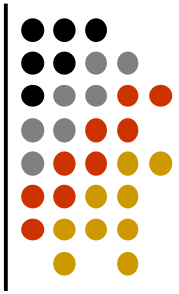


Pultruded profiles section resistance



- In pultruded profiles section resistance is governed by local buckling.

- A simple way of taking into account local buckling is considering that section resistance is the minimum between material resistance σ_{ult} and elastic buckling stress σ_{cr}.

$$\sigma_{cr} = K \frac{\pi^2 \sqrt{E_{L,c} E_{T,c}}}{12(1 - \nu_{LT} \cdot \nu_{TL})} \left(\frac{t}{b}\right)^2$$

K ➔ buckling coefficient

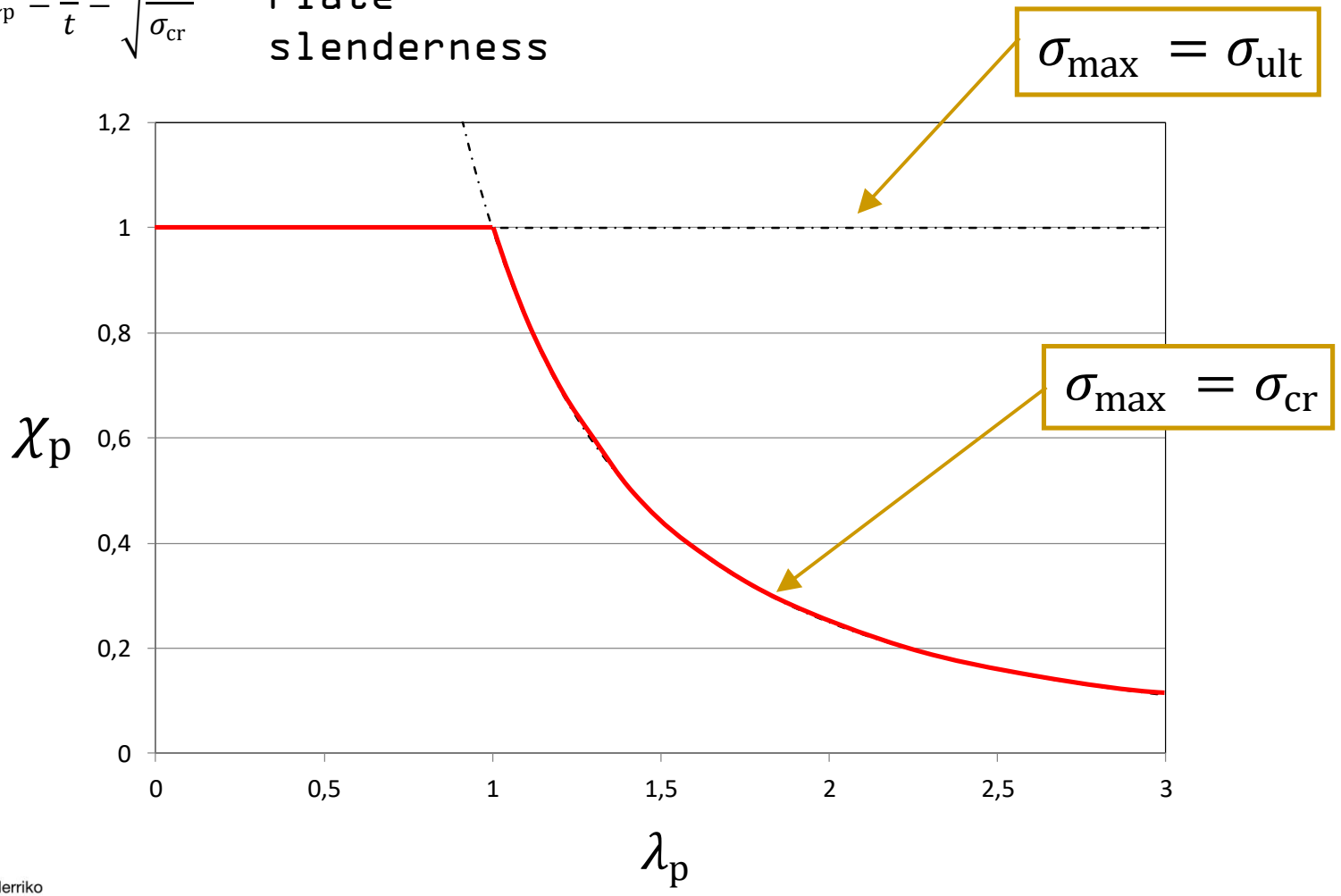
Pultruded profiles section resistance

$$\sigma_{max} = \chi_p \sigma_{ult} \rightarrow \chi_p = \frac{\sigma_{max}}{\sigma_{ult}}$$

Local buckling reduction factor

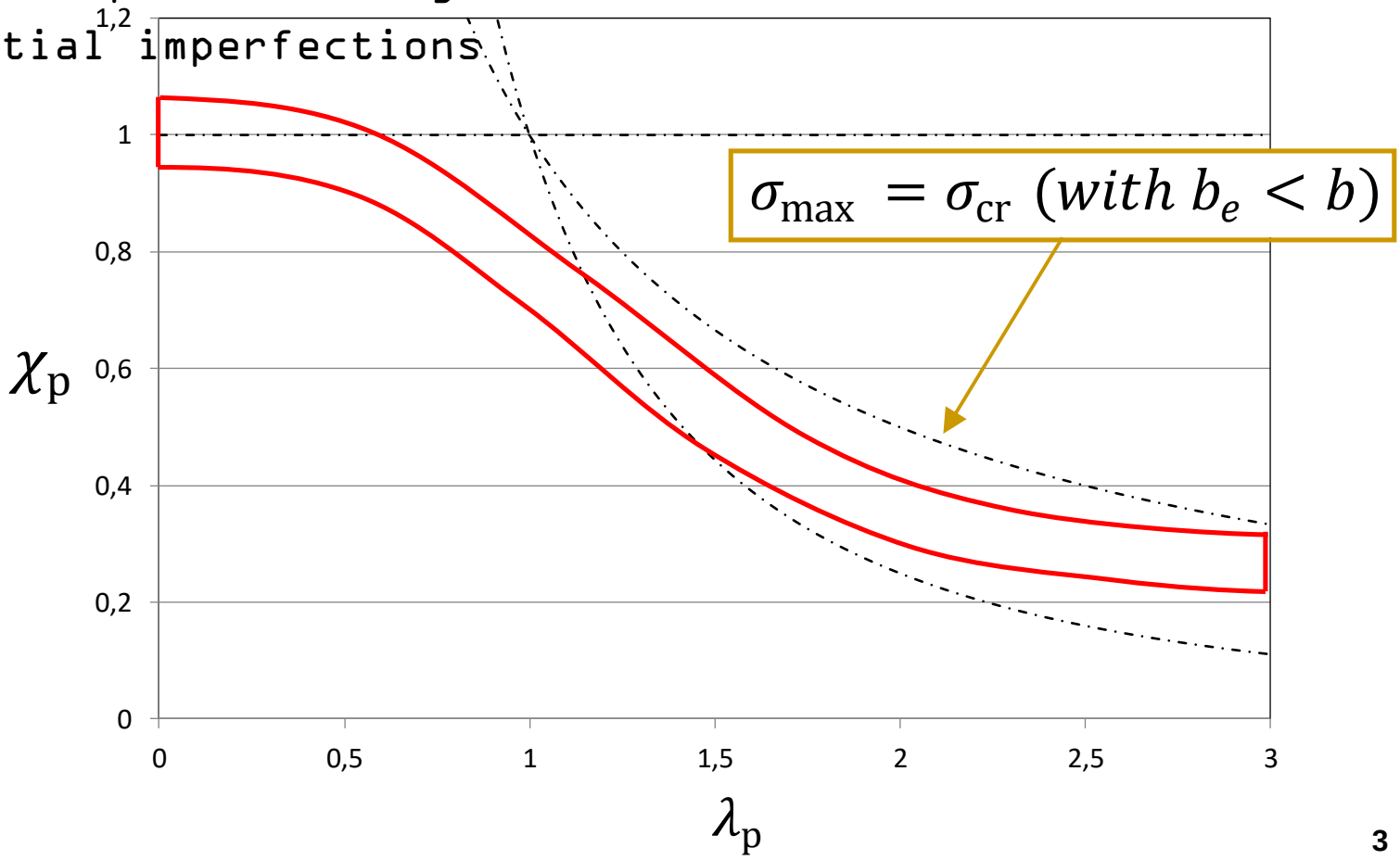
$$\lambda_p = \frac{b}{t} = \sqrt{\frac{\sigma_{ult}}{\sigma_{cr}}}$$

Plate slenderness

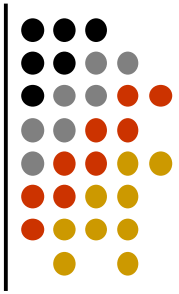


Pultruded profiles section resistance

- Another method is the effective width, including:
  - Stable post-buckling
  - Initial imperfections



Objective of the work



- To predict section resistance based on experimental data obtained from literature.

- Only open section elements in pure compression have been considered.

Methodology

- Generate an experimental data database with test results available in literature.
- Calculate the difference with the elastic buckling stress curve.
- Adjust new $\chi_p - \lambda_p$ curves minimizing the difference.

Experimental data database

Label	σ_{max}	χ_P	σ_{cr}	λ_P	Difference %
Y-1 [2]	85,10	0,31	48,31	2,4	43,23
Y-2 [2]	76,65	0,28	45,35	2,47	40,84
Y-3 [2]	132,97	0,46	111	1,62	16,52
Y-4 [2]	73,00	0,37	44,96	2,1	38,41
Y-5 [2]	78,16	0,31	46,14	2,33	40,97
Y-6 [2]	67,67	0,29	33,3	2,64	50,79
Y-7 [2]	83,79	0,33	34,1	2,73	59,3
Y-8 [2]	141,07	0,61	90,32	1,6	35,98
BR1 [3]	47,56	0,17	35,49	2,78	25,38
BR2 [3]	42,51	0,15	35,49	2,78	16,51
BR3 [3]	46,20	0,17	35,49	2,78	23,19
BR4 [3]	51,75	0,19	35,49	2,78	31,42

- [2] Yoon, S. J., Local buckling of pultruded I-shape columns PhD Dissertation (1993).
- [3] Barbero, E. J., and Raftoyiannis, I. G., Local Buckling of FRP Beams and Columns. Journal of Materials in Civil Engineering, 5(3), 339-55 (1993).

Experimental data database

Label	σ_{max}	χ_P	σ_{cr}	λ_P	Difference %
TB1-a [4]	135,91	0,49	84,79	1,8	37,61
TB1-b [4]	123,60	0,45	84,79	1,8	31,4
TB1-c [4]	100,32	0,36	84,79	1,8	15,48
TB1-d [4]	123,40	0,45	84,79	1,8	31,29
TB2-a [4]	64,10	0,23	40,46	2,61	36,88
TB2-b [4]	64,21	0,23	40,46	2,61	36,98
TB2-c [4]	61,08	0,22	40,46	2,61	33,76
TB2-d [4]	60,62	0,22	40,46	2,61	33,25
TB2-e [4]	62,48	0,23	40,46	2,61	35,24
TB2-f [4]	51,33	0,19	40,46	2,61	21,18
TB2-g [4]	53,41	0,19	40,46	2,61	24,25
TB2-h [4]	58,08	0,21	40,46	2,61	30,34
TB2-i [4]	54,56	0,20	40,46	2,61	25,84
TB3-a [4]	145,59	0,53	86,14	1,79	40,83
TB3-b [4]	126,76	0,46	86,14	1,79	32,05
TB3-c [4]	114,17	0,42	86,14	1,79	24,55
TB4-a [4]	73,83	0,27	48,55	2,38	34,24
TB4-b [4]	72,22	0,26	48,55	2,38	32,78
TB4-c [4]	60,02	0,22	48,55	2,38	19,11

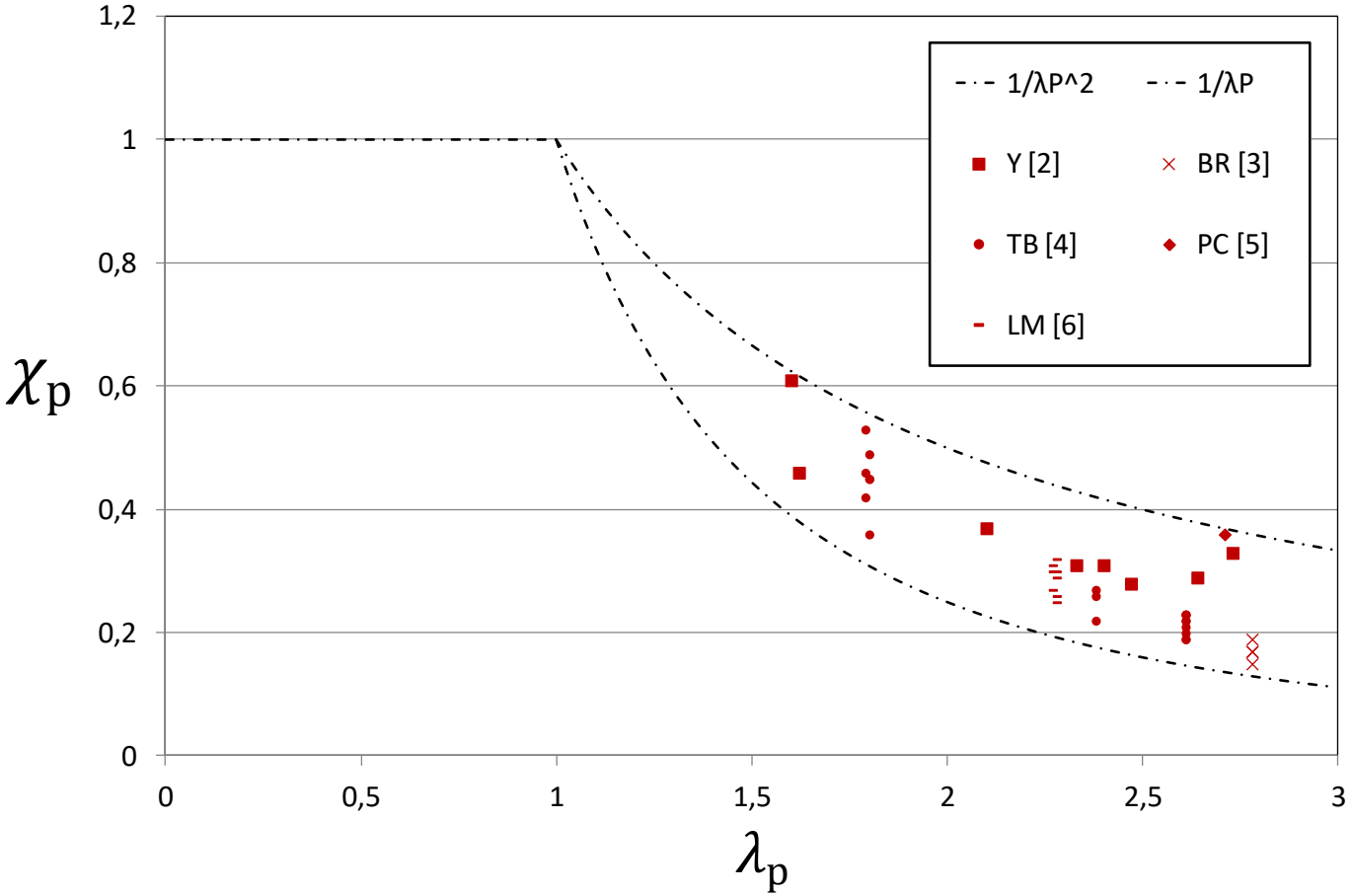
- [4] Tomblin, J., and Barbero, E., Local Buckling Experiments on FRP Columns. Thin-Walled Structures, 18(2), 97-116 (1994).

Experimental data database

Label	σ_{max}	χ_P	σ_{cr}	λ_P	Difference %
PC1 [5]	109,08	0,36	40,87	2,71	62,53
LM-A [6]	74,18	0,27	53,19	2,27	28,3
LM-B [6]	72,13	0,26	52,97	2,28	26,57
LM-C [6]	68,47	0,25	53,02	2,28	22,56
LM-D1 [6]	80,72	0,29	52,97	2,28	34,38
LM-D2 [6]	81,66	0,30	52,97	2,28	35,14
LM-E1 [6]	88,84	0,32	53,02	2,28	40,32
LM-F1 [6]	83,36	0,30	53,4	2,27	35,95
LM-F2 [6]	85,55	0,31	53,4	2,27	37,58

- [5] Pecce, M., and Cosenza, E., Local Buckling Curves for the Design of FRP Profiles. Thin-walled structures, 37(3), 207-22 (2000).
- [6] Lane, A., and Mottram, J. T., Influence of Modal Coupling on the Buckling of Concentrically Loaded Pultruded Fibre-Reinforced Plastic Columns. Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications, 216(2), 133-44 (2002).

Experimental data database



$$\chi_p = \frac{1}{\lambda_p{}^2}$$ ⟹ Average difference 36.75 %

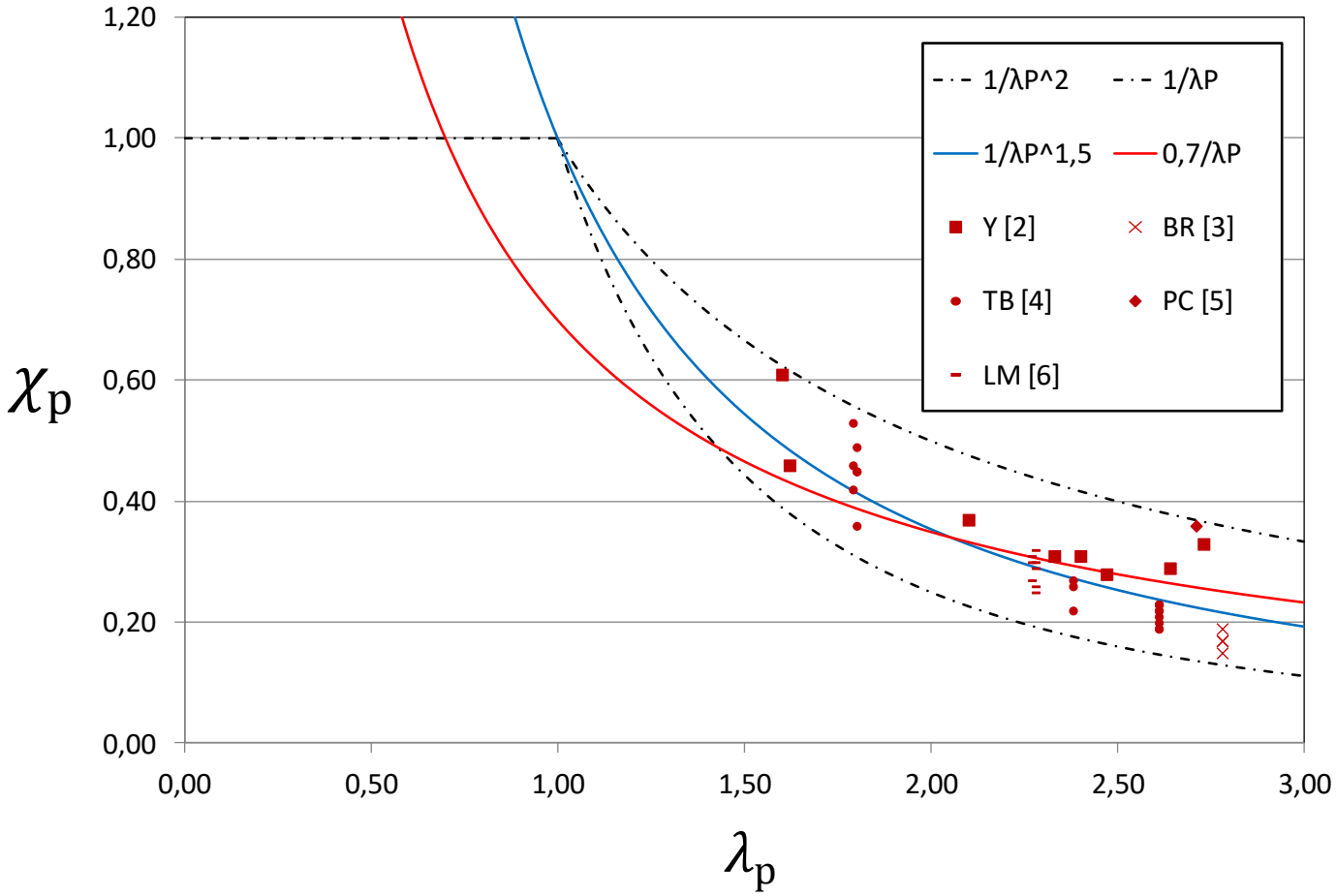
Design approach

- General curve between the theoretical upper and lower bounds in high $\lambda\lambda_p$ values

$$\chi_p = \frac{K}{\lambda_p{}^n}$$

- n = 1.5 minimizes the absolute difference $\chi_p = \frac{1}{\lambda_p{}^{1.5}}$
- K = 0.7 minimizes the absolute difference $\chi_p = \frac{0.7}{\lambda_p}$

Experimental data database



$$\chi_p = \frac{1}{\lambda_p^{1.5}} \Rightarrow \text{Average difference } 14.26\ \%$$

$$\chi_p = \frac{0.7}{\lambda_p} \Rightarrow \text{Average difference } 20.22\ \%$$

CONCLUSIONS AND FUTURE WORK

- An experimental data database has been generated for open section pultruded elements in compression.
- The experimental results have been compared with the elastic buckling stress.
- Two new curves have been adjusted based on the database.
- Next step should be to identify the plate slenderness limit to consider local buckling.
- Plate's effective width could be defined for pultruded sections beyond this limit.

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