Master's Thesis Engineering Technology

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Optimal stiffness of longitudinal stiffeners in girders subjected to patch loading

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Master of Civil Engineering Technology

1. Introduction

I. BACKGROUND

- Hungarian bridges are build using an incremental launching method, causing a temporary patch loading condition
- Longitudinally stiffened girders are used to resist against patch loading

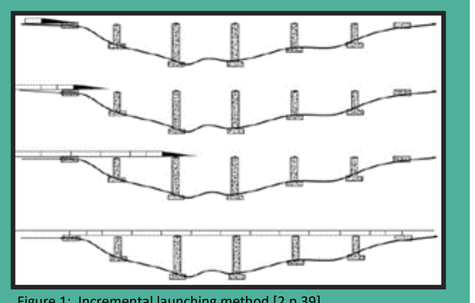

Figure 1: Incremental launching method [2,p.39]

II. PROBLEM

- Design method for longitudinally stiffened girders in EN 1993-1-5 underestimates the patch loading resistance
- EN 1993-1-5 only handles girders with one longitudinal stiffener
- EN 1993-1-5 does not take different failure modes into account

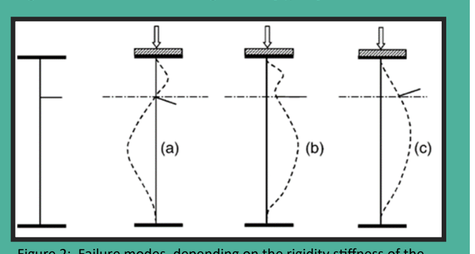

Figure 2: Failure modes, depending on the rigidity stiffness of the stiffener: a) local buckling, b) interaction of local and global buckling, c) global buckling [3, p. 564]

III. GOAL

- Analyse the influence of different parameters on the patch loading resistance
- Proposal of new formulation for "strong" or "weak" longitudinal stiffeners

[1,p.1]

2. Method

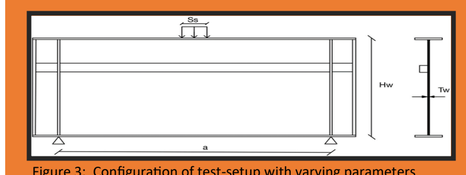

Figure 3: Configuration of test-setup with varying parameters

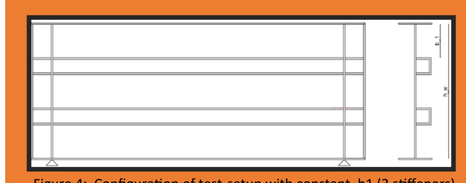

Figure 4: Configuration of test-setup with constant b1 (2 stiffeners)

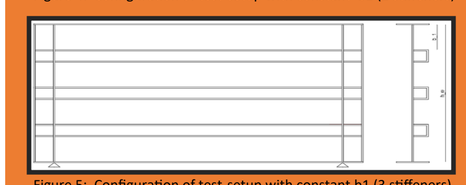

Figure 5: Configuration of test-setup with constant b1 (3 stiffeners)

I. Model development

- Longitudinally stiffened girder developed in ANSYS
- Geometrically and Materially Nonlinear Imperfection Analysis (GMNIA) and Linear Buckling Analysis (LBA)

II. Model validation

- Validated with experiments of Seitz.
- Manual imperfections (1 global imperfection, 3 local imperfections)
- Comparison numerical results vs. experimental results

III. Parameter identification

- Investigating the parameters given in the current EN 1993-1-5 formulation in function of the optimal stiffness
- Chosen parameters / ratio: loaded length (s_s), length (a), height (h_w), thickness web (t_w) and height loaded subpanel over thickness web (b_1/t_w)

$$\gamma_{s\_opt\_EC} = 13\left(\frac{a}{h_w}\right)^3 + 210\left(0{,}3 - \frac{b_1}{a}\right)$$

3. Results & Discussion

I. Influence of b_1/t_w - ratio

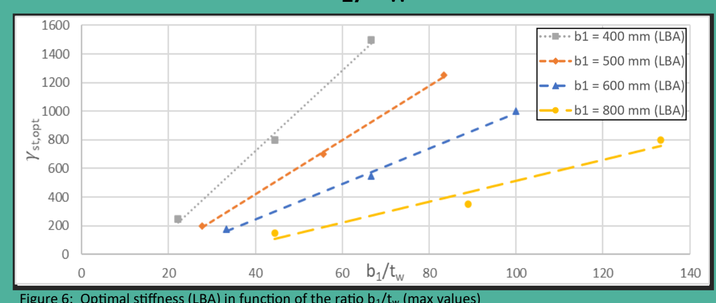

Figure 6: Optimal stiffness (LBA) in function of the ratio b_1/t_w (max values)

II. Influence of s_s , a, h_w and t_w

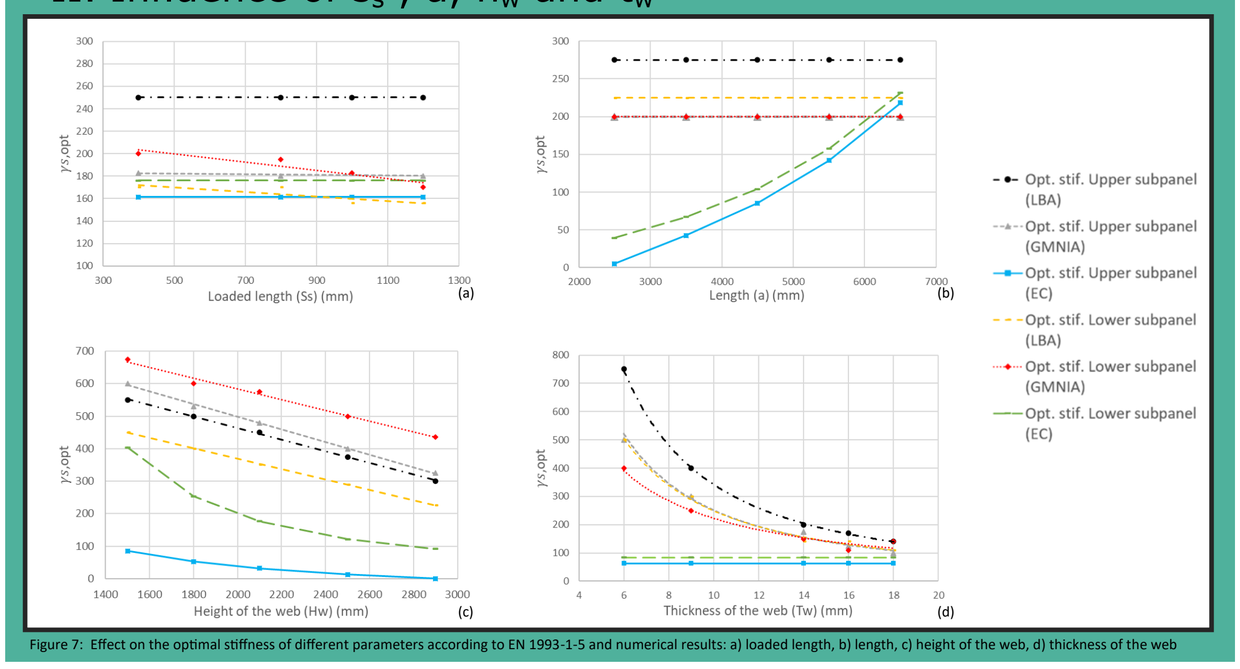

Figure 7: Effect on the optimal stiffness of different parameters according to EN 1993-1-5 and numerical results: a) loaded length, b) length, c) height of the web, d) thickness of the web

4. Conclusion

I. Parameters

- Loaded length: no influence
- Length of the girder: 1/a increasing influence
- Height of the web: $1/h_w$ decreasing influence
- Thickness of the web: $1/t_w$ decreasing influence

II. New criteria for "strong" stiffeners

- Using most critical stiffness (GMNIA)
- Based on b_1/t_w - ratio
- Usable for (1), 2 and 3 stiffeners
- More accurate than EN 1993-1-5 criteria $\gamma_{s\_opt} = b1 * \left(\frac{3 * 10^6}{b_1^{1.968} * tw}\right) + 135$

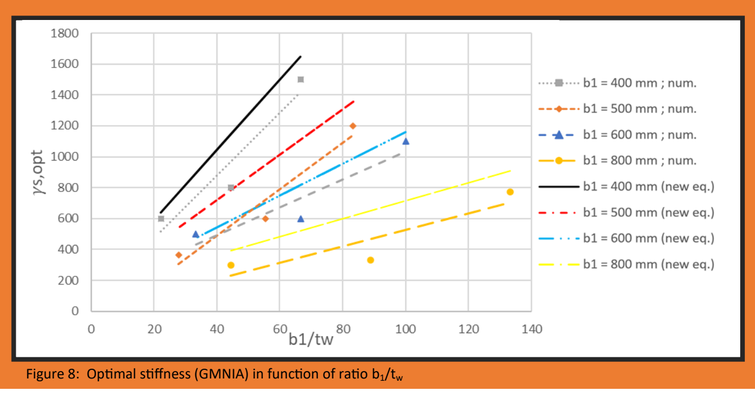

Figure 8: Optimal stiffness (GMNIA) in function of ratio b_1/t_w

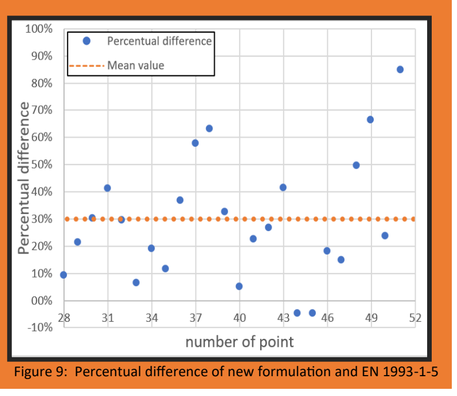

Figure 9: Percentual difference of new formulation and EN 1993-1-5

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Prof. dr. ir. Hervé Degée

[1] B. Kövesdi en L. Dunai, *Patch loading resistance of girders with longitudinally stiffened webs (powerpoint),* Munich, Germany, 2019.

[2] M. R. Hirmand, E. Rahimi, A. Moghadam en H. T. Riahi, „A mathematical investigation on the optimum design of the nose-deck system in incrementally launched bridges," *European journal of scientific research,* pp. 38-52, 2013.

[3] B. Kövesdi, *Patch loading resistance of slender plate girders with longitudinal stiffeners,* Hungary: Budapest University of Technology and Economics.

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