New production technologies and high-performance materials

Loris Saufnay

Loris.Saufnay@uliege.be
+32 4 366 9297

Prof. Jean-Pierre Jaspart
Dr. Jean-François Demonceau

PARTNERS

LIÈGE université — ArcelorMittal — greisch

General overview

By contrast with the conveyed image, the construction sector regularly evolves with a constant concern for quality, safety and, of course, for economic efficiency. As a matter of fact, steelmakers are, nowadays, able to produce more resistant steels through more efficient processes. In recent years, the research interest is focused on two aspects which are: the impact of new production processes on member stability and the economic benefit in using high strength steel in steel structures.

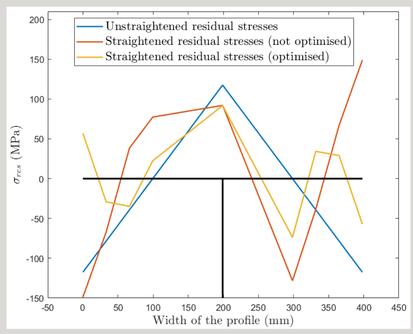
1. Some relevant statistics [1]

- **1868,8 Mt** : is the world crude steel production reached in 2019.
- **20%** : is the expected percentage of the steel demand increase by 2050 in order to meet the future needs of our growing population.
- **52%** : is the percentage of the world steel market dedicated to building and infrastructures.
- **~75%** : is the percentage of the 3500 steel grades in use today which did not exist 20 years ago.
- **1/3** : is the steel need at present if the Eiffel tower were to be rebuild today.
- **50%** : is the potential reduction percentage which can be achieved by substituting regular steels for Advanced High-Strength Steels to build high-rise buildings.

According to these facts, today's society depends on steel, and it seems essential to pursue the steel production development in such a way to increase the steel strength-to-weight ratio in order to make energy, weight, environmental and economical savings.

2. New production technologies

In this part, the impact of new processes such as the **roller-straightening process** or the **oxy-cutting** on the resistance of members is investigated. Indeed, such processes may reduce the amplitude of residual stresses at flange tips that could lead to an increase in the column bearing capacity, in particular of the member sensitive to instabilities. However, these possible positive effects have not yet been deeply studied and still need to be mastered. It is proposed to perform the required investigations within the thesis to highlight the possible positive effects of these processes and to propose analytical methods to account for these effects.



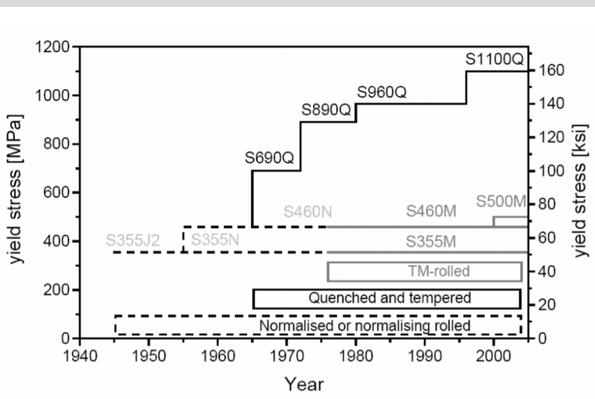
Effect of the roller-straightening on a residual stress pattern.

3. Benefit of High Strength Steels

The use of such high strength steels can lead to:

- Material saving
- More slender elements
- Lightweight structures and thus lower foundations
- Lower transport and fabrication costs
- More usable space for a given building height or by floor (reduction of the column cross-sections)

However, the interest in using such steel is not necessarily obvious as phenomena such as instabilities, fatigue or deflection requirements considerably limit the advantage of high strength steels. It is for this reason that the designer is sometimes reluctant in using them as, up to now, he has no clear indications when the use of such steels is of interest.



Evolution of the steel grade over time.

Various steel sections subjected to various loading which are regularly met in steel structures will be considered to clearly identify the domains for which the use of high strength steels present an economic benefit.

En1993-1-1 : S235 to S460
En1993-1-12 : S500 to S700
} Now

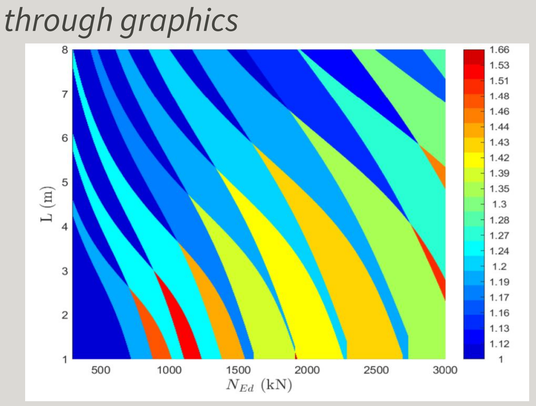
En1993-1-1 : S235 to S700
En1993-1-12 : S700 to S960
} Next generation

4. Some preliminary results

The final objective of the present work is to derive practical guidelines which could help designers in determining whether the use of high strength steels has an economic benefit. Two methods have been established and presented in [2-3]:

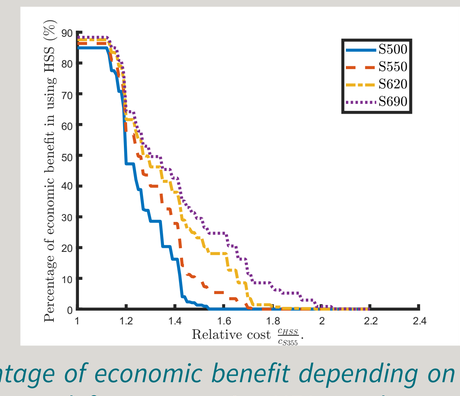
1. *Direct determination of optimum profiles for both compared steel grades through numerical or graphical tools*

2. *Direct determination of the weight ratio between the two optimum profiles through graphics*



Example of a chart displaying the weight ratio between an optimized solution using "classical" S355 steel and an optimized high strength S500 steel for member in compression. From this weight ratio, it is then possible to highlight the zone of economic benefit in using S500 steel solutions.

Sensitivity studies in order to evaluate the impact of a cost variation on the economic benefit in using high strength steels are also conducted.



Percentage of economic benefit depending on the HSS yield strength for compression HEA member.

References

[1] World Steel Association: https://www.worldsteel.org/
[2] Saufnay, L. (2021). Economic benefit of high strength steel sections for steel structures. Ce/papers., 4(2-4), 1543–1550. https://doi.org/10.1002/cepa.1454
[3] Saufnay, L. (2019), Interest of high strength steel rolled sections for steel structures (in French), Master's thesis presented at University of Liège (http://hdl.handle.net/2268/250358)

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