

A close-up photograph of a hot dip galvanized steel surface. The surface is covered in a thick, crystalline zinc coating. Several circular rivets or bolts are visible, some of which are partially covered by the zinc coating. The background is a dark, textured greenish-grey.

Hot dip galvanizing of high strength steel

Hot rolled steel products



SSAB is a global steel company with a leading position in high-strength steels and related services.

SSAB in brief

129 BILLION
SEK
Revenue in 2022



Annual steel
production capacity:
8.8 MILLION
TONNES

Steel making since
1878

14,500
professionals
in over 50 countries

OUR BUSINESSES:
SSAB Special Steels,
SSAB Europe,
SSAB Americas, Tibnor,
Ruukki Construction



First in fossil-free steel

Galvanizing of high strength steel





Resource efficiency applies to both production and end products.

- ▶ SSAB's production is among the most efficient in the world.
- ▶ With our steel, end-users can use less steel to create lighter products with longer lifetimes.

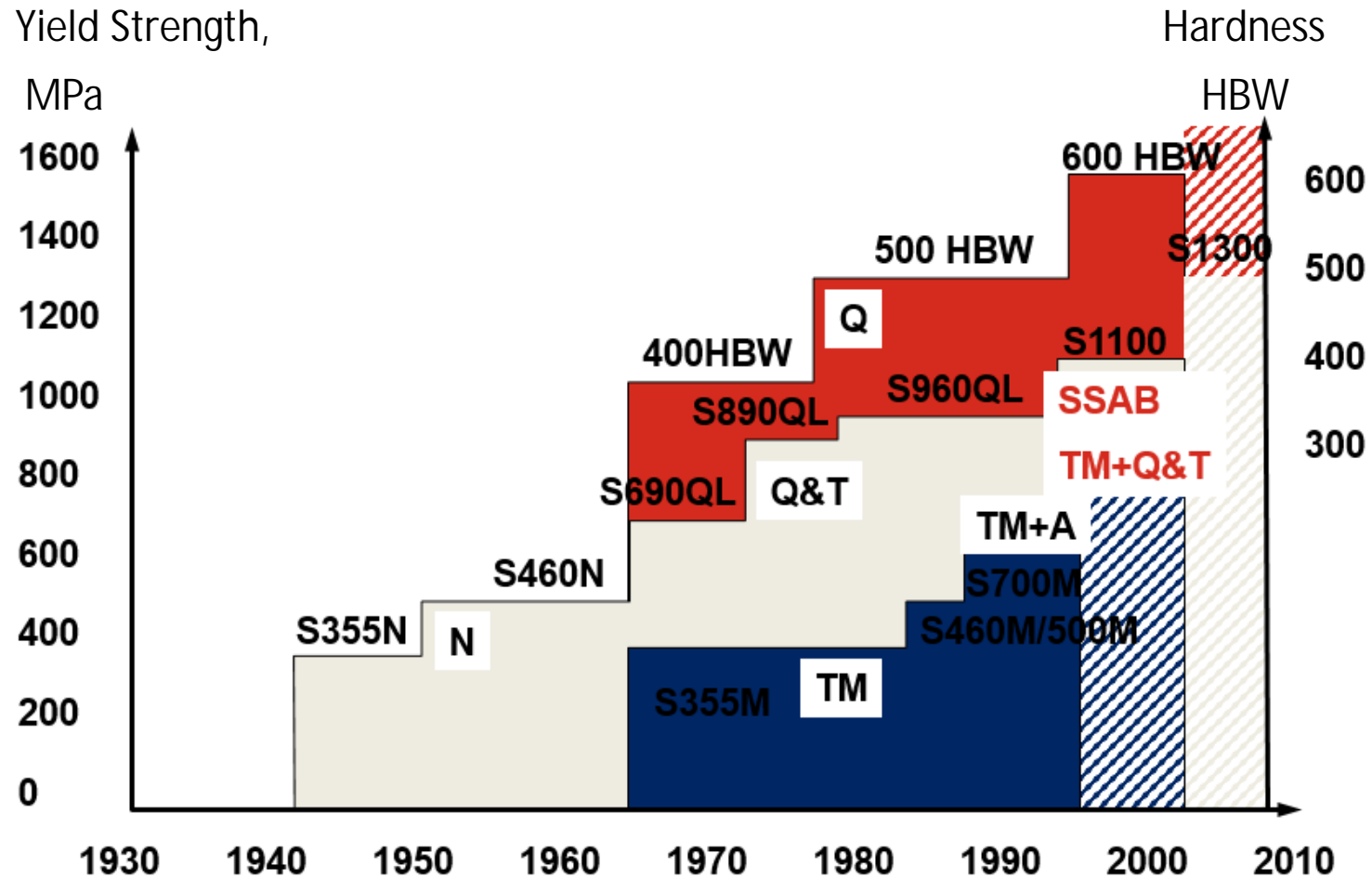
SSAB steel makes products stronger, lighter and increases productivity

High-strength steels decrease CO₂ emissions

High-strength steels made trailer shed saves over half a tonne of weight. The increased productivity saves 12,000 liters of fuel and 30 tonnes of CO₂ during 12 years of operation.

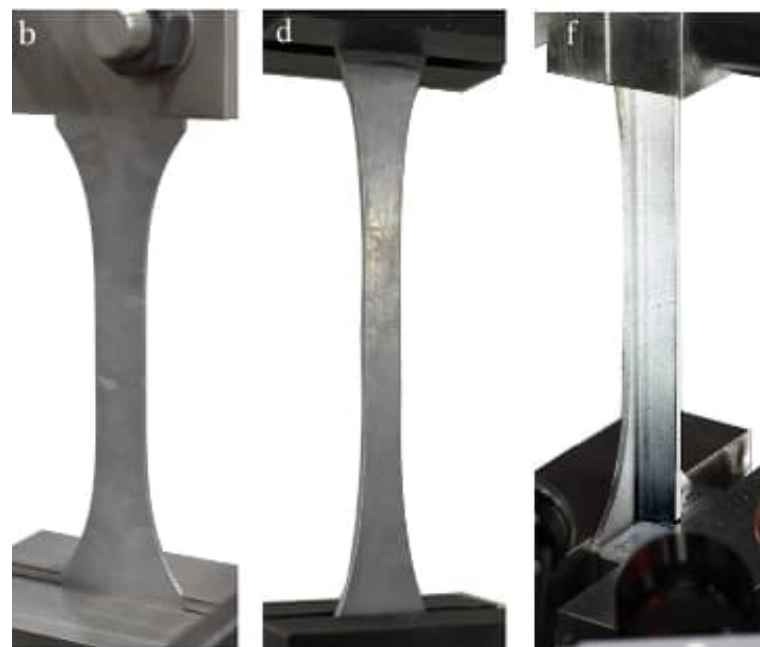
- ▶ Less use of steel
- ▶ Saving of natural resources
- ▶ More payload
- ▶ Cost savings
- ▶ Less CO₂ emissions
- ▶ Longer lifetime for the product

Development of steel strength



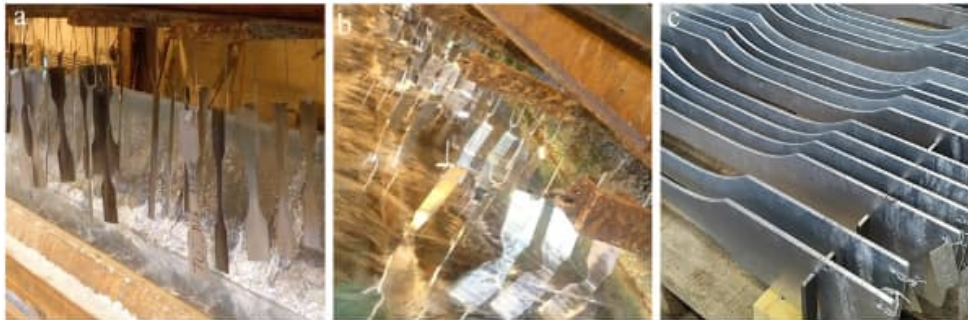
Long term work for galvanizing of high strength steels

- ▶ Projects over 15 years period
- ▶ Three public funded projects
- ▶ Literature surveys
- ▶ Several thesis works



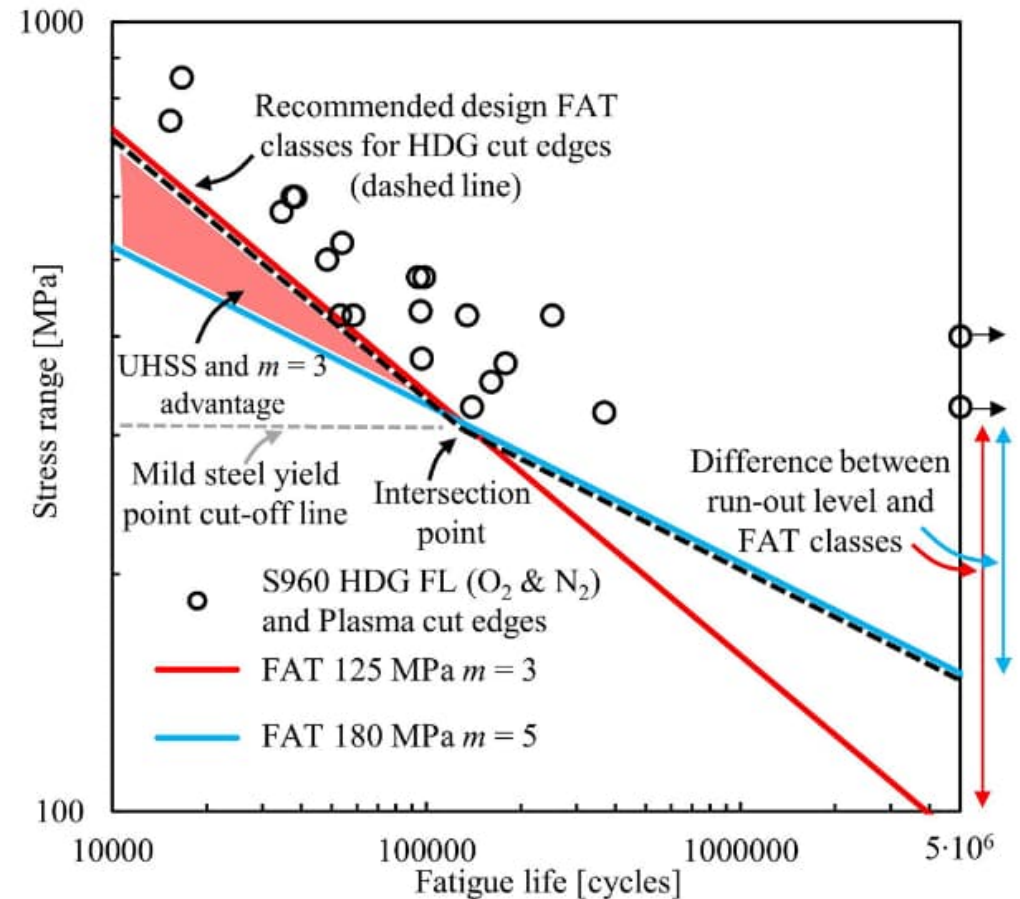
Development during work

- ▶ In the beginning:
 - not possible or very challenging of galvanizing steel over 460 MPa yield strength
- ▶ Nowadays galvanizing up to 700 MPa yield strength steels is quite common
- ▶ Need to upgrade for 900 - 960 MPa steels



Latest work

- ▶ Thesis work in Metropolia University of Applied Sciences
 - Small steel structures made of 960 MPa were galvanized and studied
- ▶ Fatigue strength of hot dip galvanized 700 MPa and 960 MPa steels –project in Lappeenranta University of Technology
 - Different cutting methods and the effect of welding studied
 - Main outcome: No change in fatigue life of 700 MPa steel – one class lower fatigue class used for design with 960 MPa steel



Challenges of hot dip galvanizing high strength steels

- ▶ Hydrogen embrittlement HE
- ▶ Liquid metal embrittlement LME

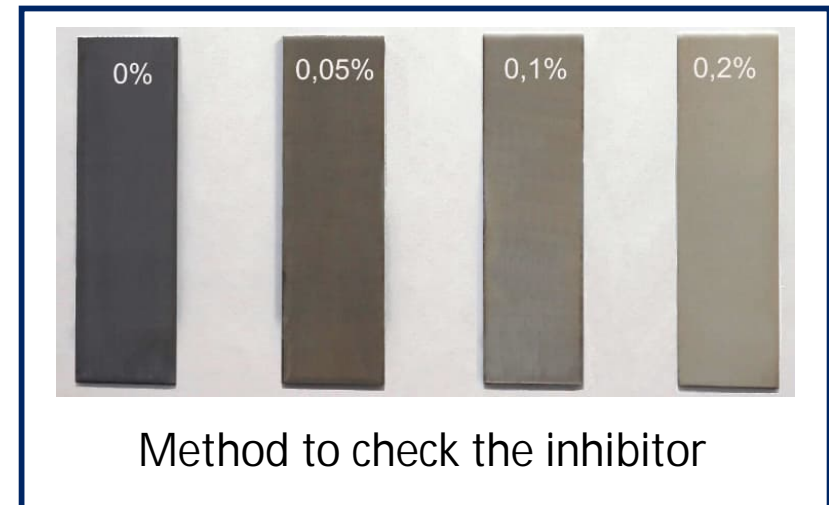
Both can be controlled!

- ▶ Flat products well suitable for galvanizing
- ▶ Hollow sections still more challenging



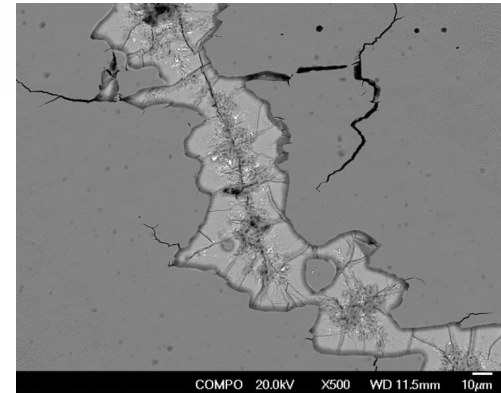
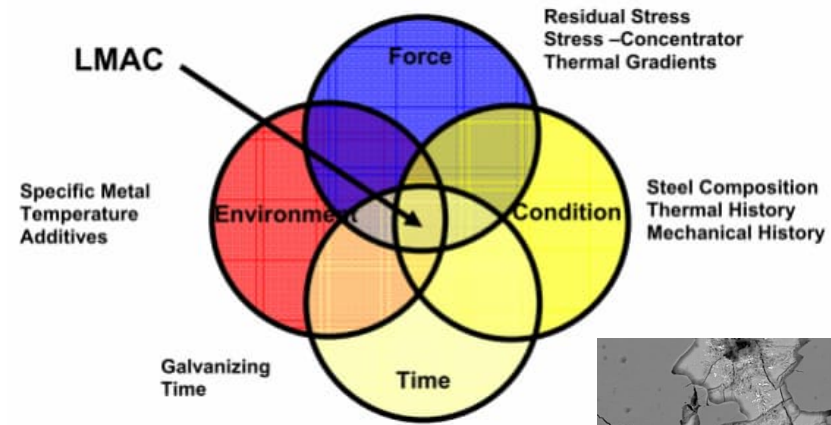
Hydrogen embrittlement

- ▶ Delayed fracture..
- ▶ The higher strength steel – the higher sensitivity
- ▶ Can be easily controlled by..
 - Using dry steel and welding consumables
 - Using steel free of organic impurities
 - Adding effective pickling inhibitor to pickling bath (e.g. hexamethylene tetramine)
- ▶ Easy method to check the inhibitor



Liquid Metal Embrittlement

- ▶ Prevention begins from designers desk:
 - The more simple structure – the better
 - Avoid stress concentrations
 - Rounded cutting edges
- ▶ Quality of cut edge is very important:
 - Laser cutting is the most recommended method for industrial use
- ▶ Recommendation for composition of zinc bath: Sn < 0,3 %, Bi < 0,1 %, Pb < 0,9 %
- ▶ Also other factors: pre-heating, dipping angle and speed, duration of immersion..
- ▶ The effect of steel and zinc bath alloying mentioned in literature – need more research..



More information

- ▶ EGGA guidance: <https://www.galvanizingeurope.org/publications/controlling-liquid-metal-assisted-cracking-during-galvanizing-of-constructural-steelwork/>
- ▶ Publications from Lappeenranta University of Technology:
- ▶ [Fatigue strength of hot-dip galvanized S960 cut edges and longitudinal welds – ScienceDirect](#)
- ▶ https://www.researchgate.net/publication/356985113_Fatigue_strength_of_hot-dip_galvanized_S960_cut_edges_and_longitudinal_welds
- ▶ Fatigue performance of notched and hot-dip galvanized laser and mechanically cut S960 steel components considering local defects with the theory of critical distances: <https://www.sciencedirect.com/science/article/pii/S0142112322003838>
- ▶ EGINEERING thesis from Metropolia University of Applied Sciences: Liquid metal embrittlement in high strength steels: <https://www.theseus.fi/handle/10024/263458>

Conclusions

- ▶ Lighter structures require higher strength steels – increased energy and material efficiency
- ▶ Nowadays it is quite common to galvanize 700 MPa yield strength flat steels
 - Hollow sections still more challenging
- ▶ Need to upgrade for 900 – 960 MPa steels
- ▶ Hydrogen embrittlement and liquid metal embrittlement recognized with high strength steels – can be controlled
- ▶ Fatigue strength studied – no change with 700 MPa steels – one class lower fatigue class used for design with 960 MPa steels



SSAB



*A stronger,
lighter and more
sustainable world*