Building Maintenance Management for Steel Structures in Industrial Facilities

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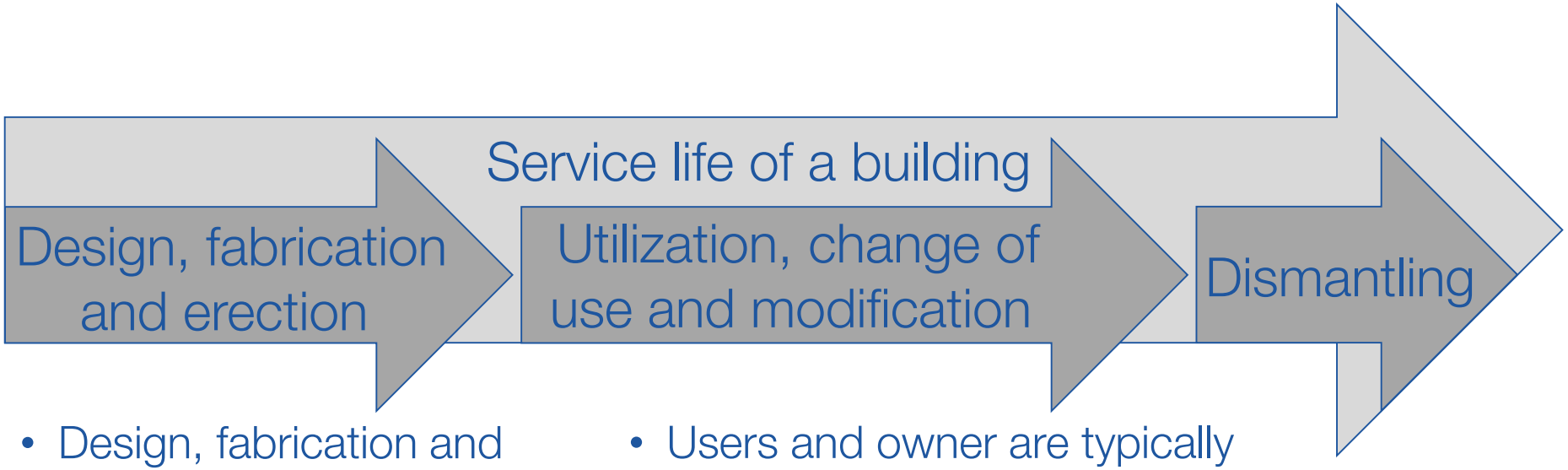
Introduction:
Service life of buildings



- Design, fabrication and erection by professionally qualified companies
- Erection process is subjected to rigorous quality assurance measures

- Users and owner are typically not structural specialists
- Utilization is rarely supervised by construction specialists, therefore limited early detection of damages

Introduction:

Reasons for the change of safety during the lifetime of a building

	Use of the Structure	Ageing of the Structure
Decreases as a result of	**Resistance (R_d)**	
	• Changes to structure, without carrying out structural checks • Damages to structure through use (e.g. impact loading) • Damages from non-use-appropriate construction	• Construction specific physical ageing (e.g. due to corrosion, abrasion, fatigue) • New findings concerning long-term behaviour of constructions materials and type of construction
	Safety against Collapse	
Increases as a result of	• Change of use	• Revaluation of load action • Change of requirements (Safety Concept)
	Action (S_d)	

=> Inspections are necessary!

Regulations and guidelines for building maintenance

Regulations and guideline for the regular inspections of buildings by the owner or an authorized representative:

- **German civil code (BGB), §823 and §836 to §838**
- **Model Building Regulations (MBO, §3, Abs.1) and the corresponding articles Building Regulations of Germany federal states (LBO‘s)**
- **VDI 6200: Structural safety of buildings – regular inspections**
- **DIN 1076: Engineering structures in connection with roads – inspection and testing**
  and the guideline for the maintenance of engineering structures RI-ERH-ING
- **Design standards, for example EN 1993-2 in association with EN 1993-1-9 for the design of crane girders**
- **Several additional Regulations and guidelines within the area of the Federal Emission control Act of Germany, for example TRAS 320**

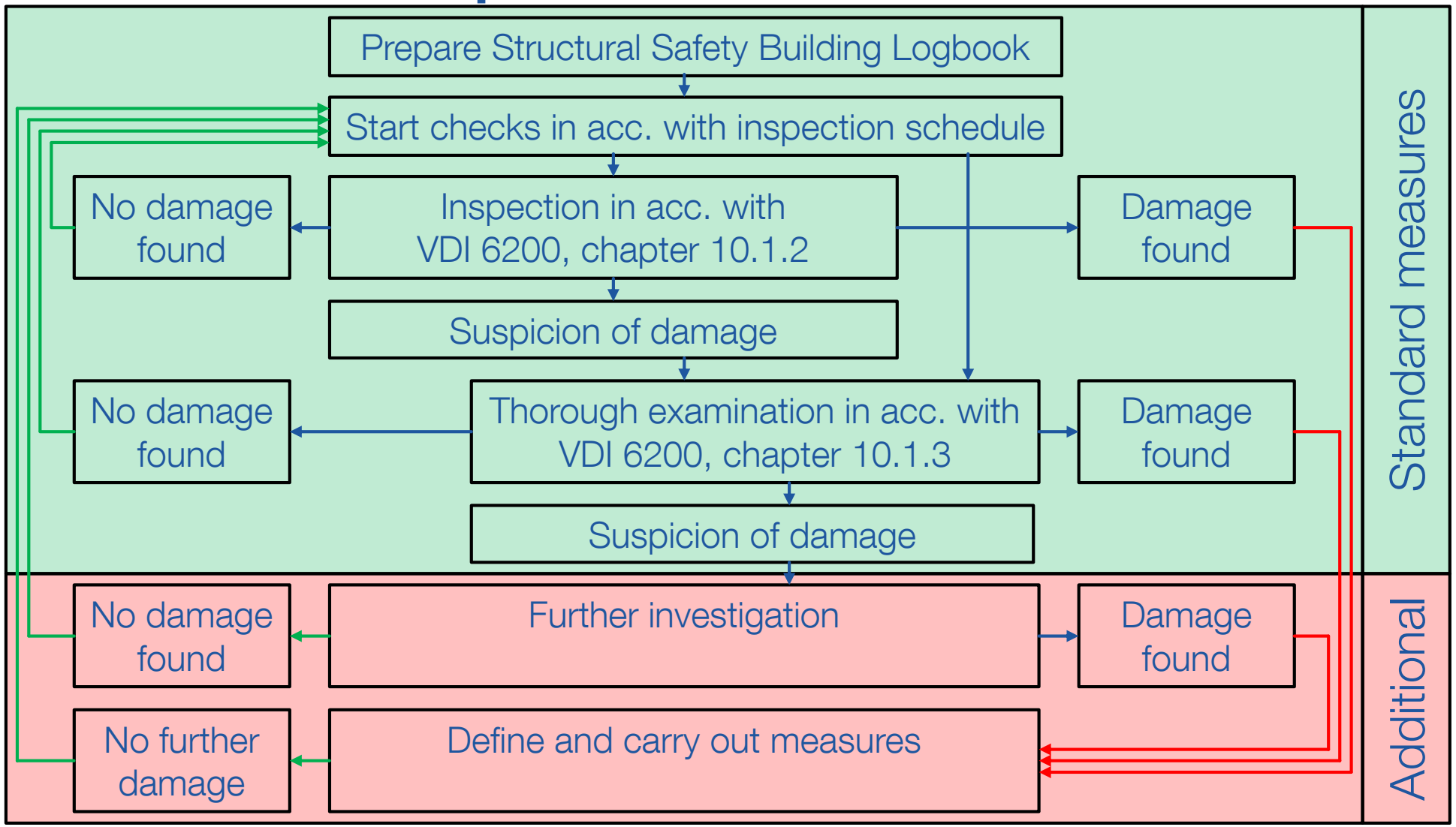
Regulations and guidelines for building maintenance

In accordance with VDI 6200 there are three types of regular inspections :

- **Surveillance by the owner/authorised representative:**
  Surveillance by the owner/authorised representative includes the inspection of the building for obvious defects or damages and the documentation thereof. This includes on the bearing structure, i. e. on all load-bearing construction elements such as supports, walls, ceilings, joists, trusses, in particular deformations, misalignments, cracks, humidity, efflorescence and corrosion.
- **Inspection by an expert:**
  The inspection by an expert is a visual inspection of the bearing structure. It is generally carried out without the use of technical test equipment.
- **Thorough examination by a special expert:**
  In the thorough inspection all of the main load-bearing elements, including those which are difficult to access, are inspected up close for weak points and damages. It may be necessary to take material samples to determine the remaining strengths and rigidities.

These inspections have to be done by an engineer with 5/10 years of practice

Flow chart of inspections



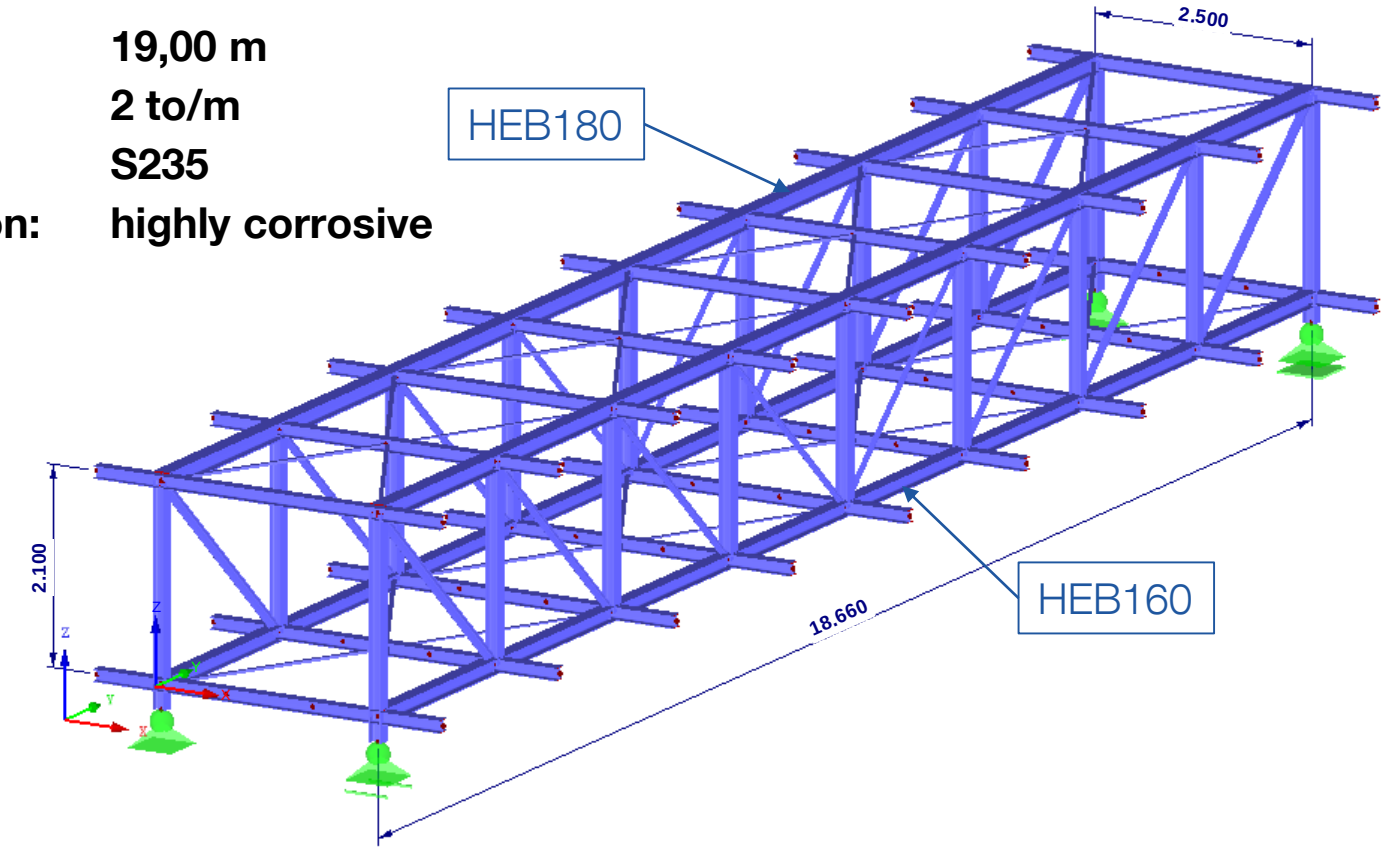
Ageing of steel structures – Example 1:

Ageing of steel structures – Example 1:

Decrease of load-bearing capacity of a pipe bridge as a result of corrosion

Example pipe bridge:

Span:	**19,00 m**
Pipe loads:	**2 to/m**
Material:	**S235**
Environmental condition:	**highly corrosive**

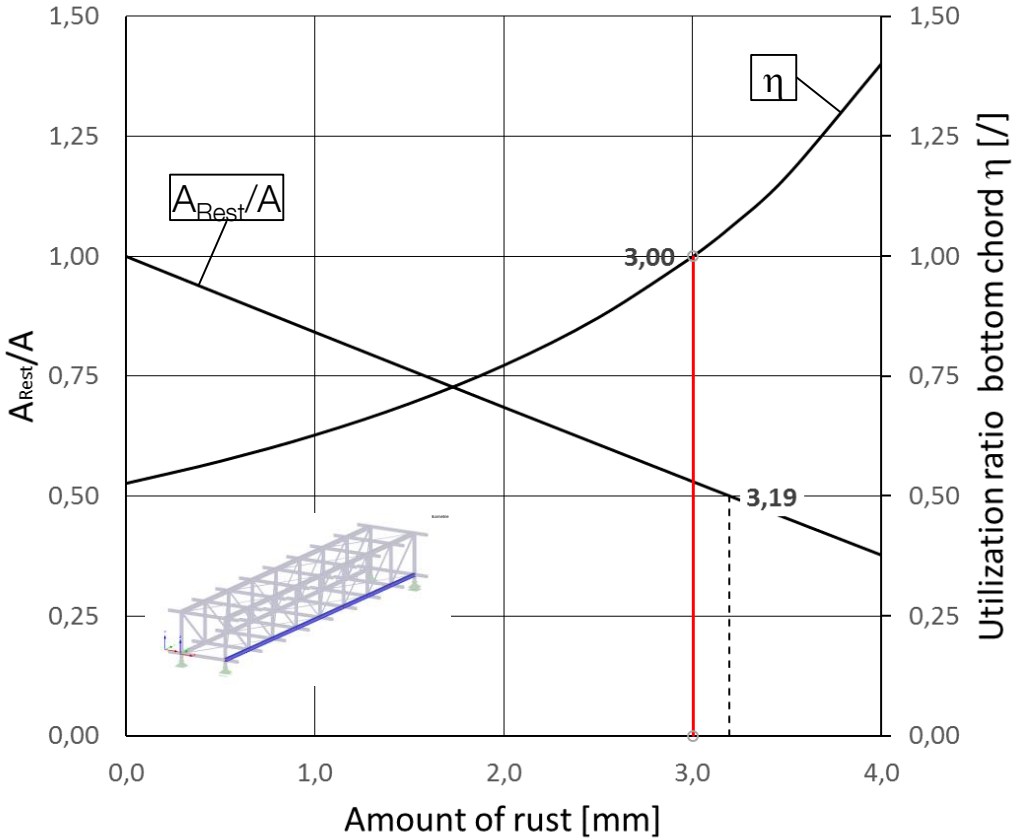


Ageing of steel structures – Example 1:

Decrease of load-bearing capacity of a pipe bridge as a result of corrosion

Impact of corrosion on the load-bearing capacity of the <u>bottom</u> chord:

- **Corrosion of an approx. thickness of 3.2 mm reduced the original cross-sectional area by half**
- **Calculations show that a corrosion of less then 3.0 mm results in the load-bearing capacity of the member under permanent and variable actions being exceeded**
- **The load-bearing capacity under exceptional / accidental actions is exceeded at a decrease in cross-section of approx. 4.0 mm**

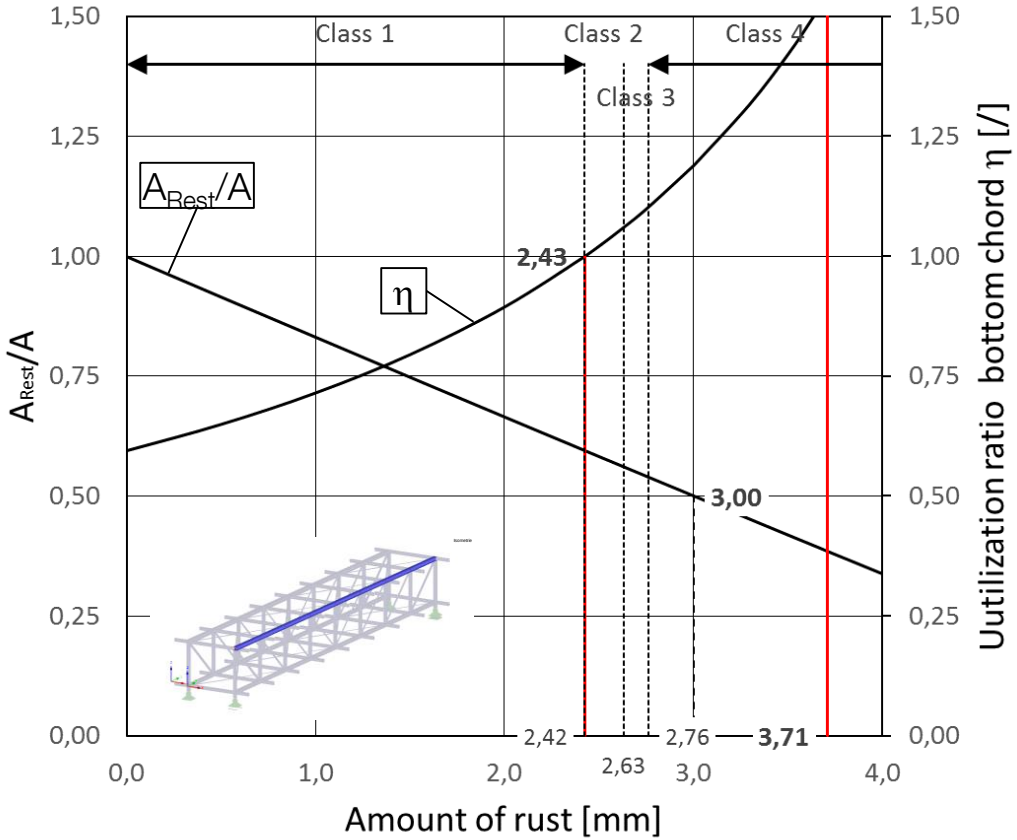


Ageing of steel structures – Example 1:

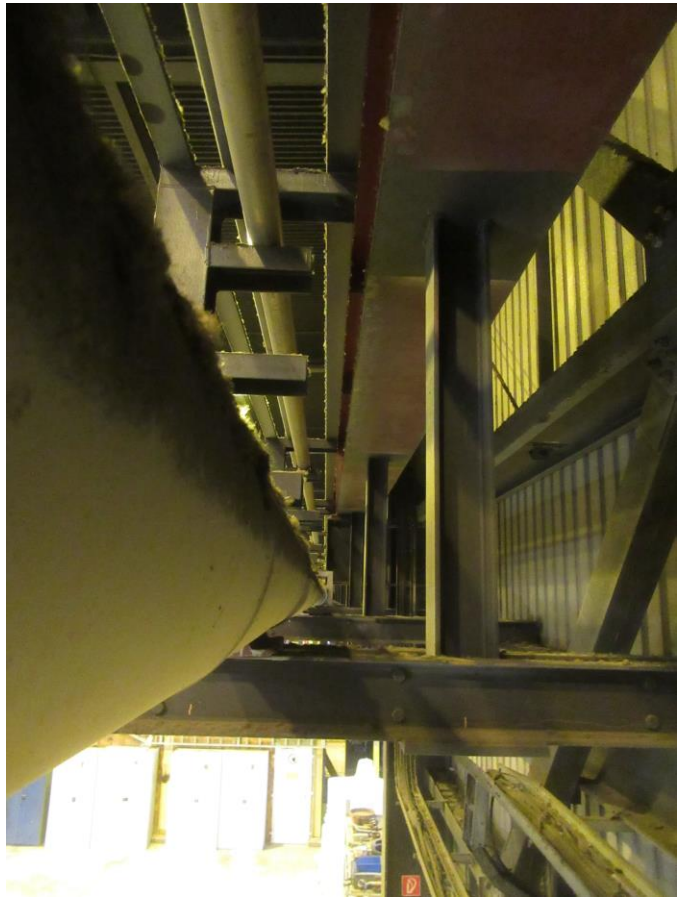
Decrease of load-bearing capacity of a pipe bridge as a result of corrosion

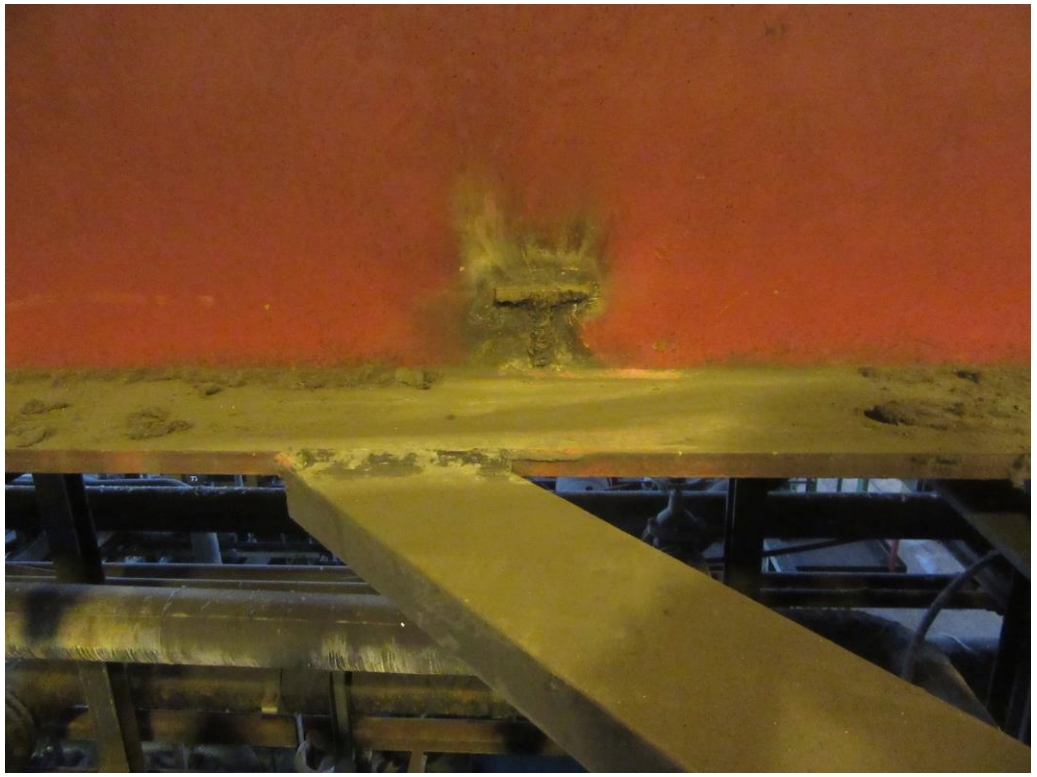
Impact of corrosion on the load-bearing capacity of the top chord:

- **Corrosion of an approx. thickness of 3.0 mm reduced the original cross-sectional area by half**
- **Calculations show that a corrosion of less then 2.4 mm results in the load-bearing capacity of the member under permanent and variable actions being exceeded**
- **The load-bearing capacity under exceptional / accidental actions is exceeded at a decrease in cross-section of approx. 3.7 mm**



Ageing of steel structures – Example 2:
Minor amendments on a crane girder





Ageing of steel structures – Example 2:

Minor amendments on a crane girder

Table 8.2: Welded built-up sections

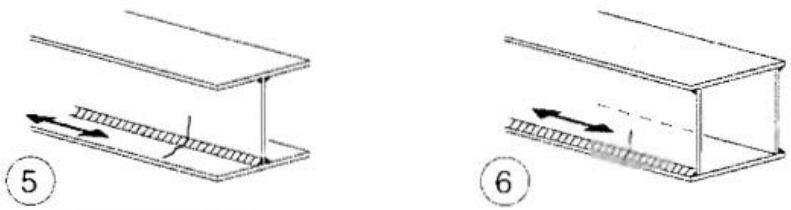
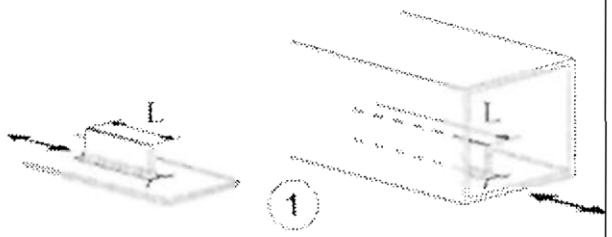
Detail category	Constructional detail	AC2 Description	Requirements
100		5) Manual fillet or butt weld. 6) Manual or automatic or fully mechanized butt welds carried out from one side only, particularly for box girders	5), 6) A very good fit between the flange and web plates is essential. The web edge to be prepared such that the root face is adequate for the achievement of regular root penetration without break-out.

Table 8.4: Weld attachments and stiffeners

Detail category	Constructional detail		Description	Requirements
80	L≤50mm		Longitudinal attachments: 1) The detail category varies according to the length of the attachment L.	The thickness of the attachment must be less than its height. If not see Table 8.5, details 5 or 6.
71	50<L≤80mm			
63	80<L≤100mm			
56	L>100mm			

- Introduction
- Regulations and guidelines
- Flow chart of inspections
- Example 1: Pipe bridge
- Example 2: Crane girder
- Summary

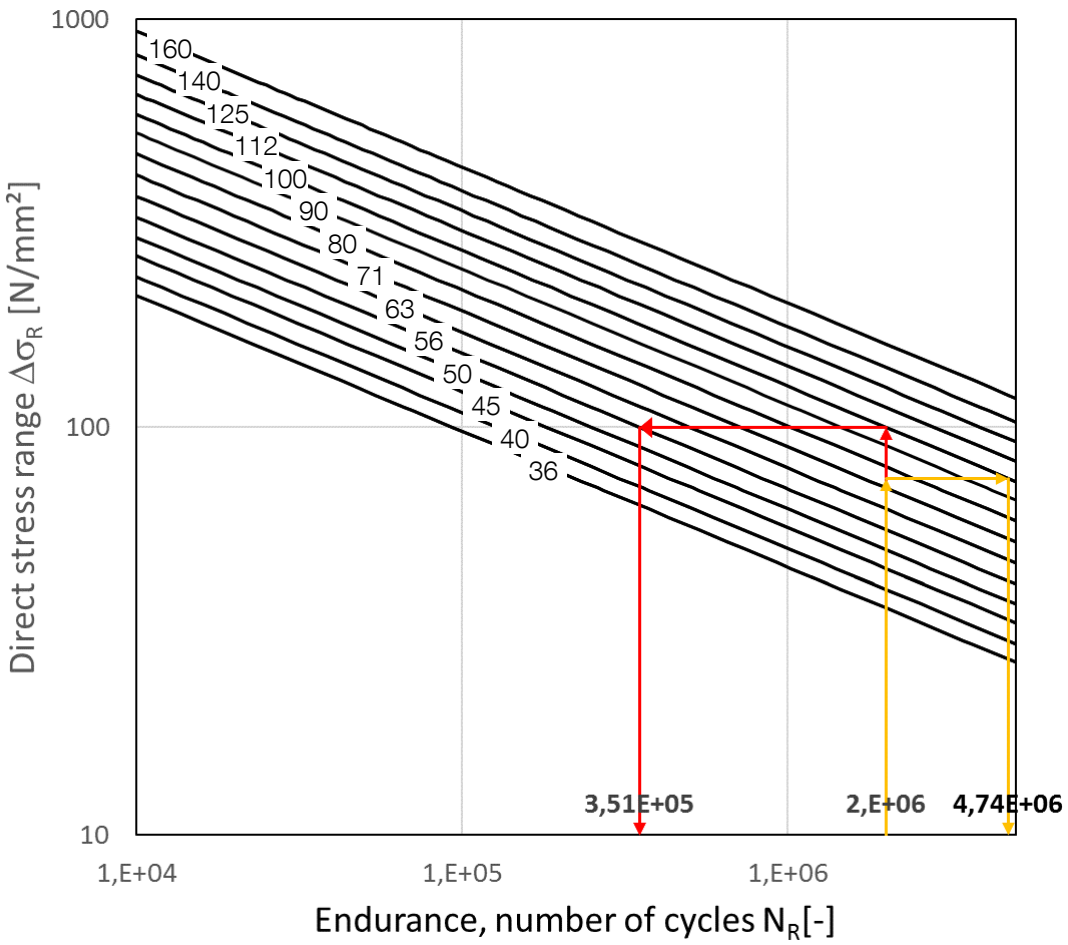
Ageing of steel structures – Example 2:

Minor amendments on a crane girder

The results of decrease of the detail category are as follows:

1. **Considering a usage ratio of 100% for fatigue calculations, the decrease of the construction detail category reduces the lifetime of the crane girder to 17% of the original lifetime**

2. **Considering a usage ratio of 75% the decrease of the detail category results in no impact on the lifetime of the crane girder**



Summary

- **The owner of a building, or its authorized representative, must ensure that its structure does not cause danger or risk to life.**
- **Such risks can be significantly reduced or prevented through proper and regular inspections.**
- **The results of inspections help with achieving an economic building management.**
- **Through early detection of damages, costs for remediation and retrofit will be reduced and utilization / availability will be increased.**
- **Thank you for your attention and have a safe trip home!**