

Demolition of the 162m high natural draft cooling tower in Mülheim-Kärlich

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CONTENT

Introduction

Survey

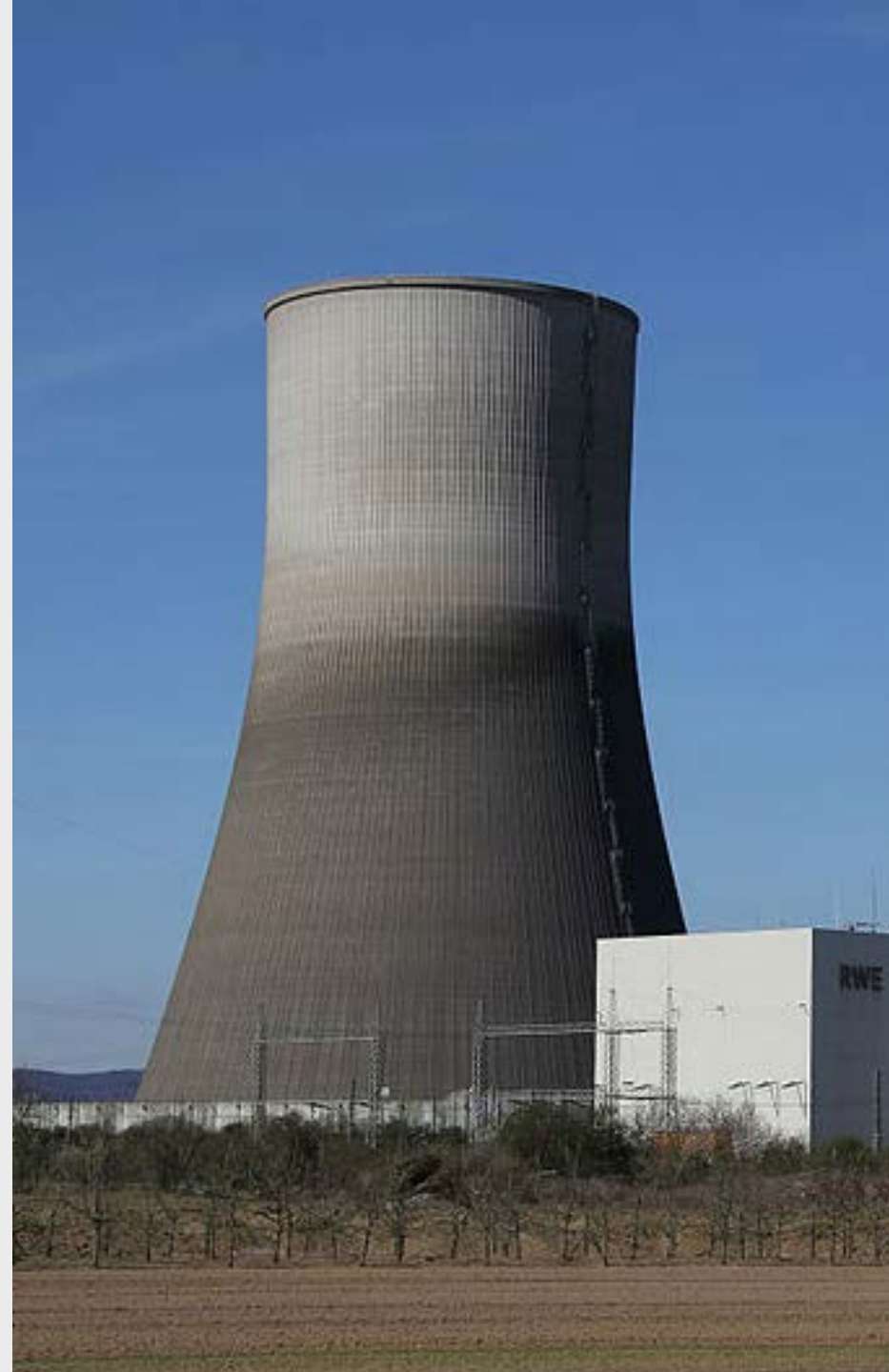
Demolition Concept

Global analysis

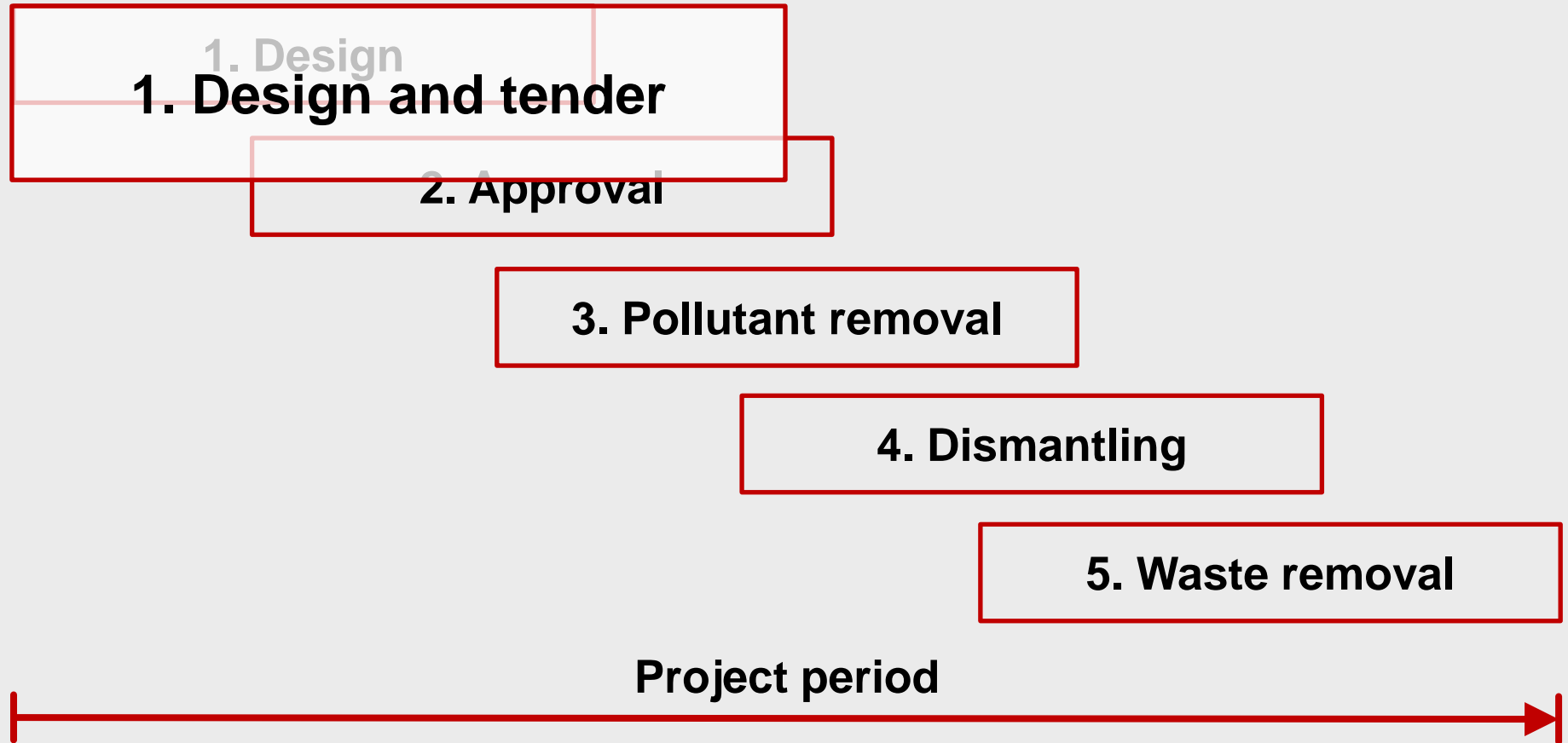
Local analysis

Time schedule

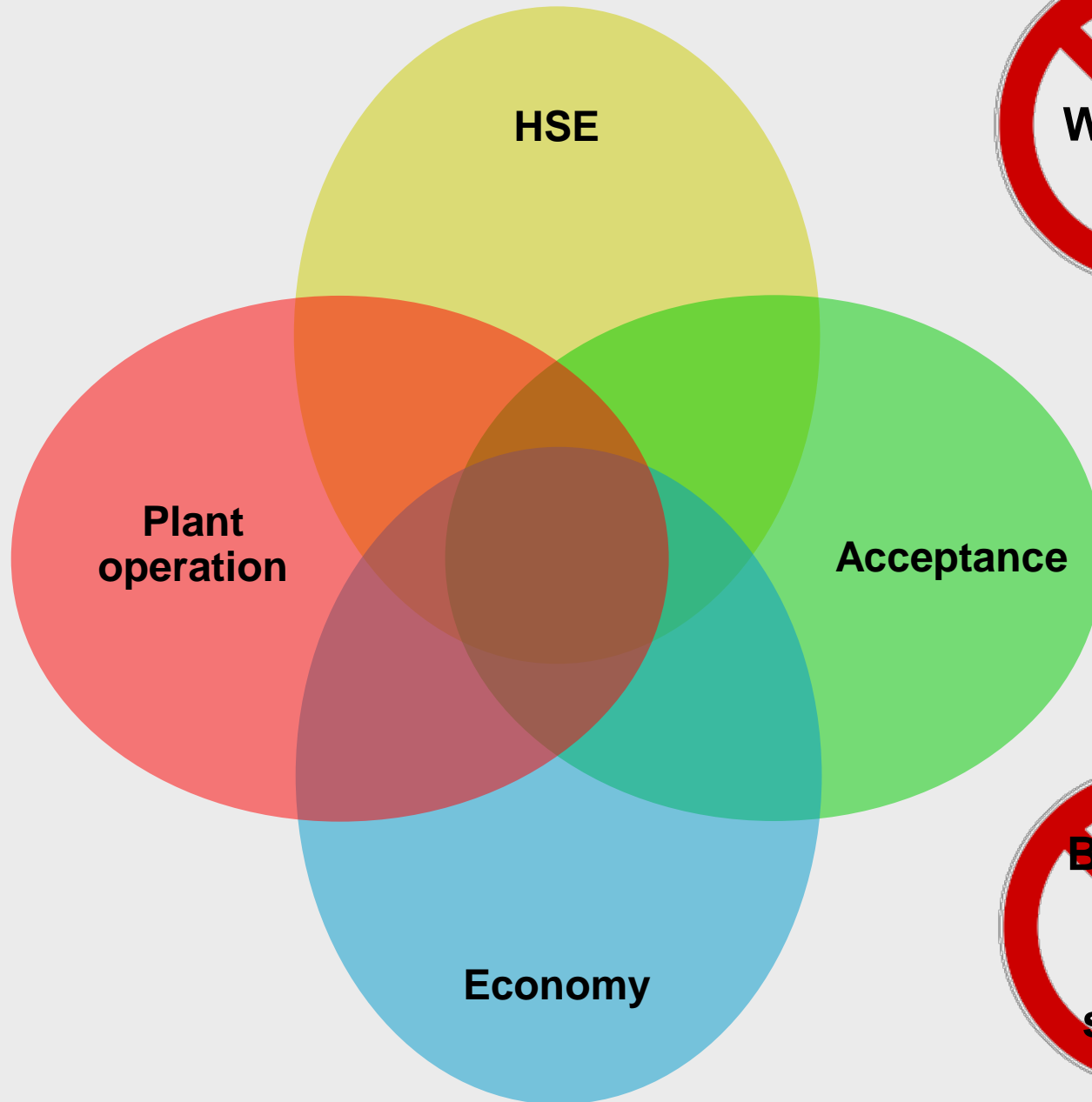
Outlook



INTRODUCTION – Project phases



INTRODUCTION – Design focus



INTRODUCTION – Design steps

1.1 Survey

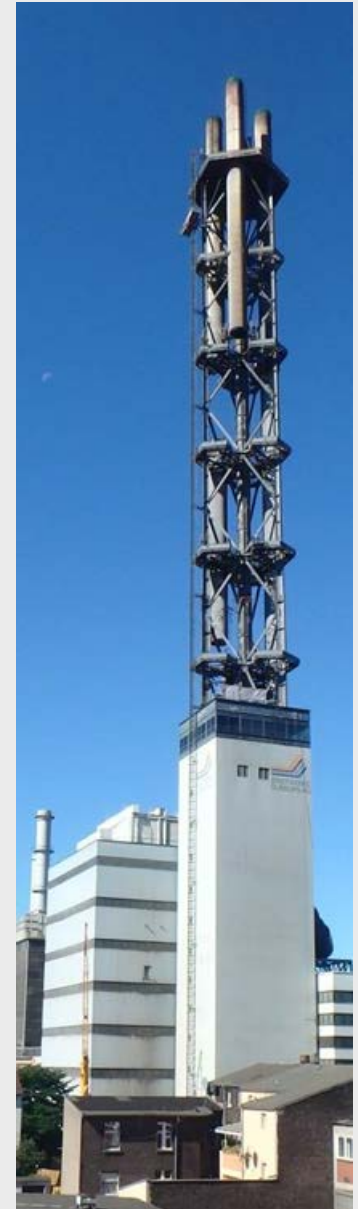
- Operation
- Structure
- Materials
- Environment
- Miscellaneous



1.2 Demolition concept

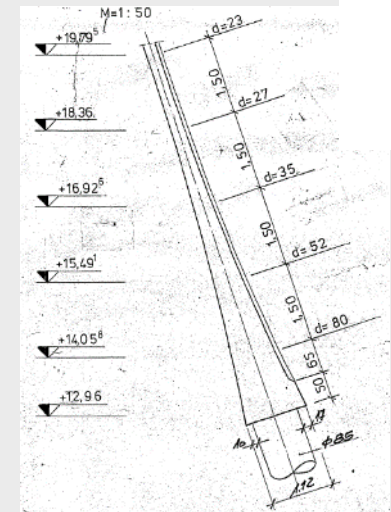
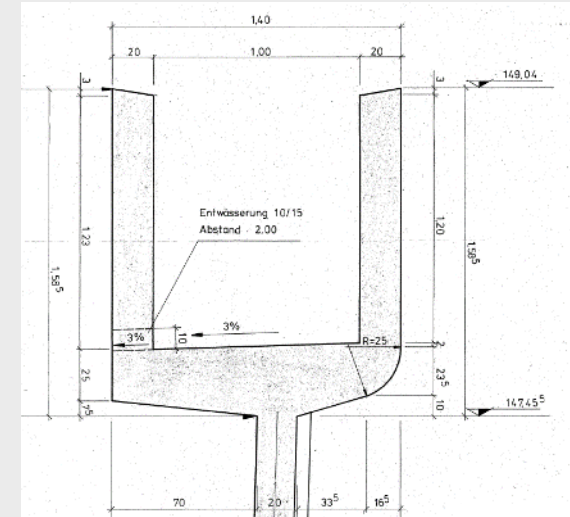
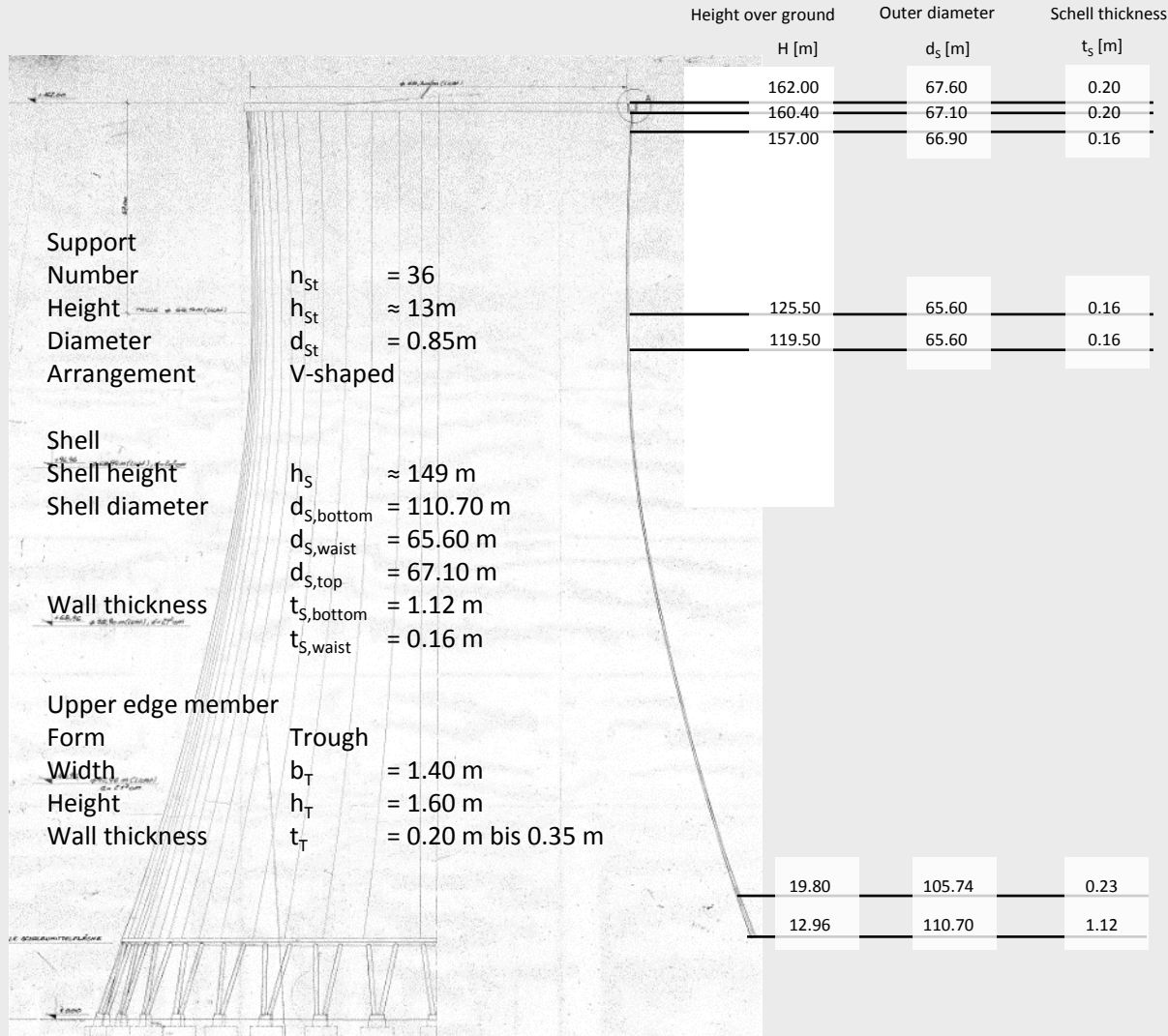


1.3 Structural analysis



DEMOLITION CONCEPT

Cooling tower dimensions



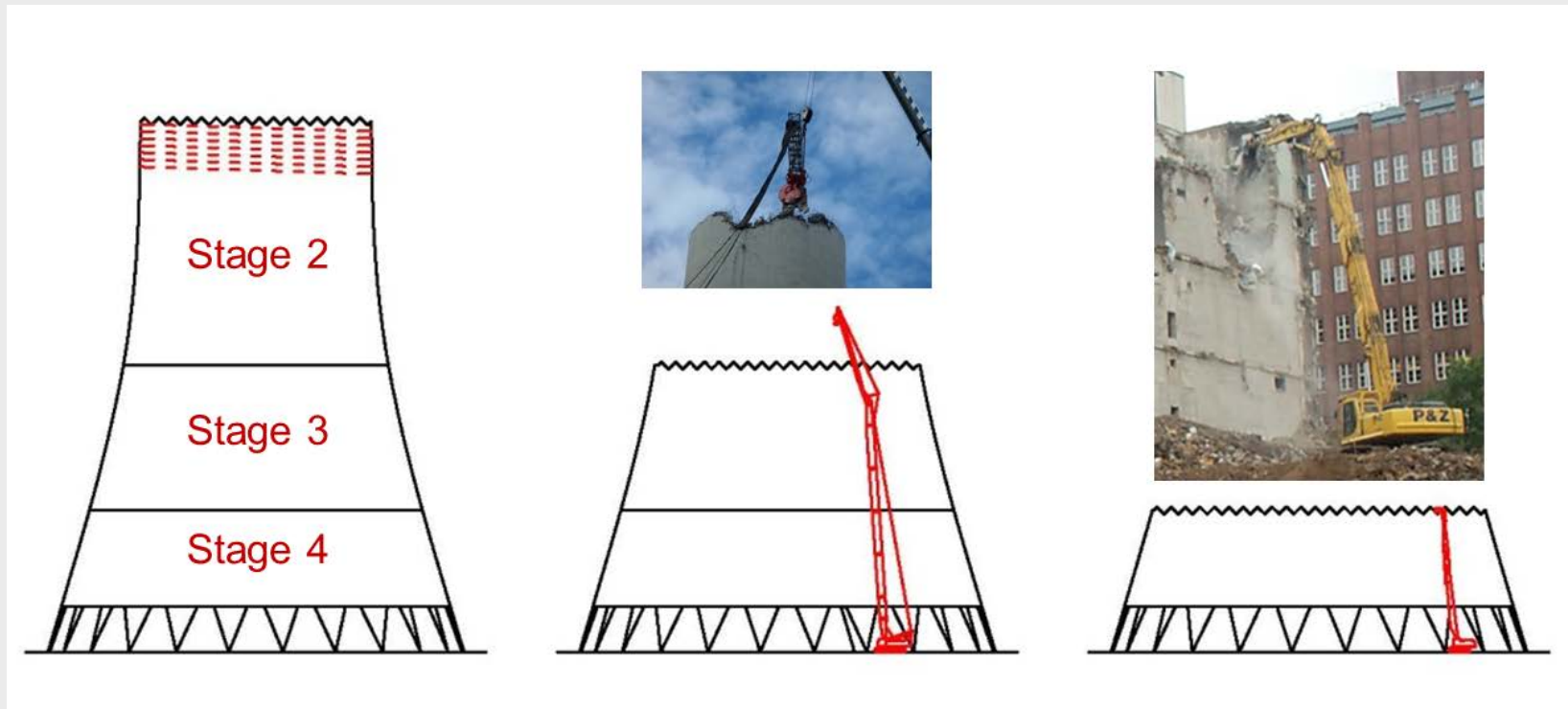
DEMOLITION CONCEPT

Decisive restrictions



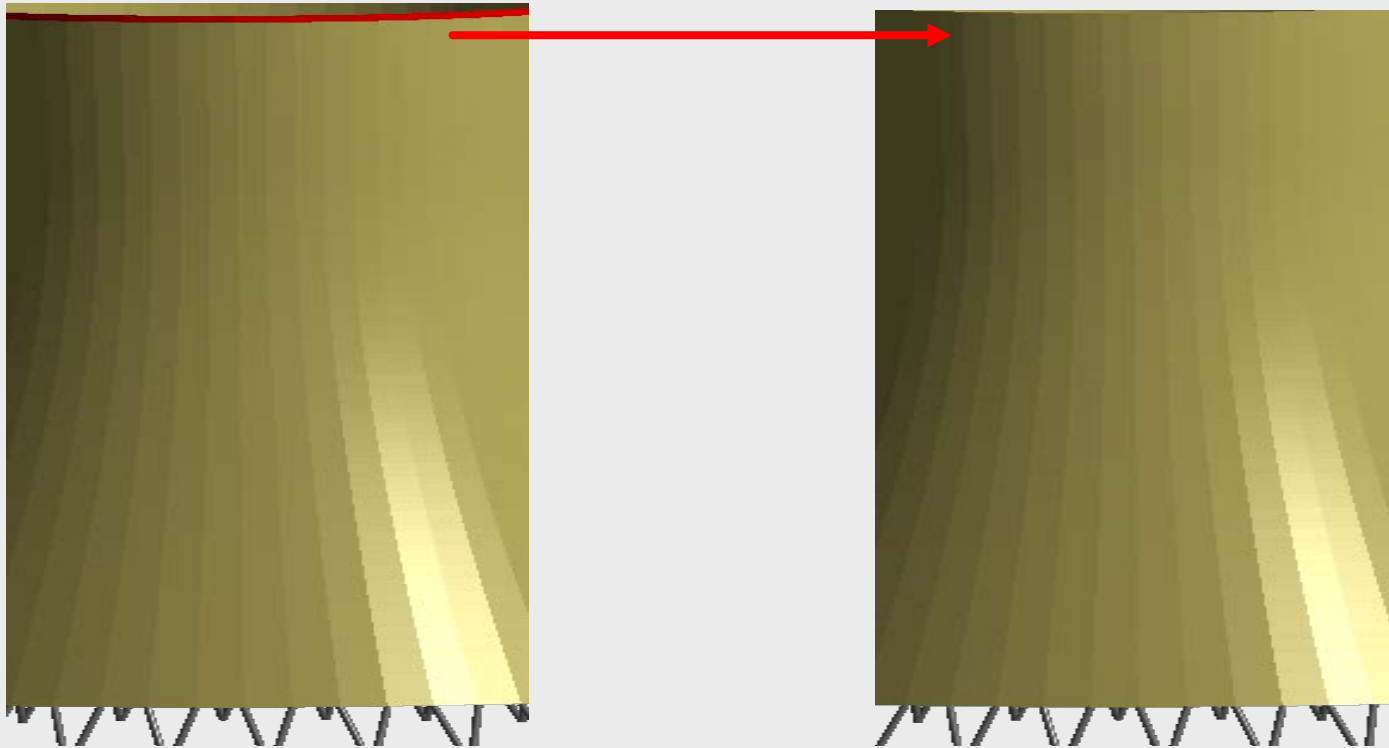
DEMOLITION CONCEPT

1. **Stage:** Dismantling the circumferential upper edge member by a mini demolition excavator, which runs in the trough section.
2. **Stage:** Dismantling the cooling tower up to 80m height by means of several special demolition excavators, which demolish the shell while spirally circulating around it.
3. **Stage:** Dismantling of the cooling tower shell up to 30m using crushers hanging on a mobile crane.
4. **Stage:** Dismantling the cooling tower up on 0m height by means of longfront excavators.



GLOBAL ANALYSIS

Relevant deconstruction situation after removal of upper edge member



Considered behavioral characteristics

- Buckling behavior
- Linear-elastic behavior in the ultimate limit state

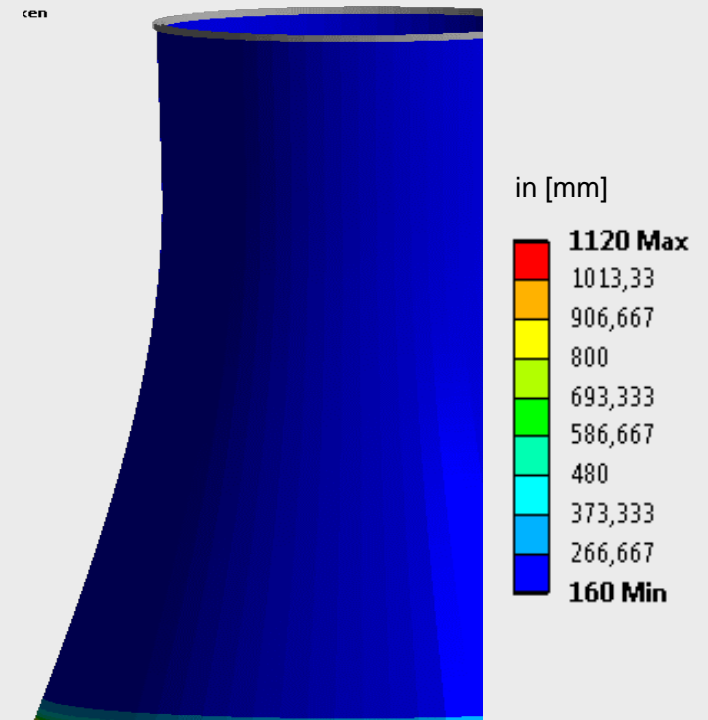
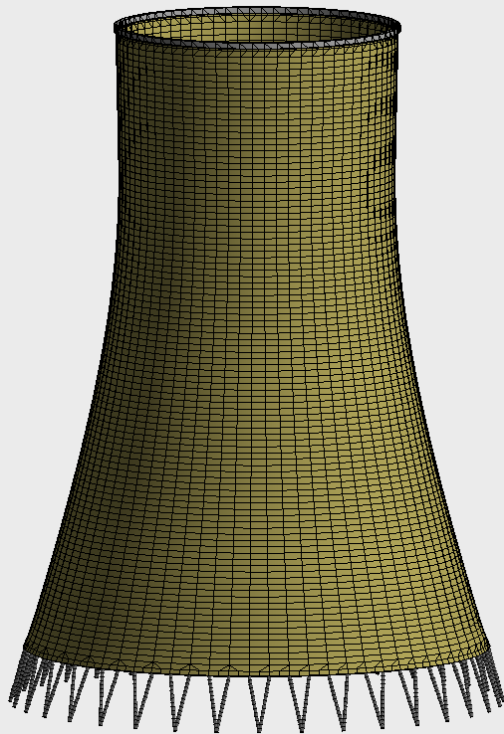
GLOBAL ANALYSIS

Modelliung with ANSYS Workbench 17.0

9338 elements with upper edge

8762 elements without upper edge

Shell elements with varying
wall thickness



GLOBAL ANALYSIS

Load cases

- G – Dead weight (approximately 225000 tons)
- W^e – External wind load
- W^i – Internal wind load (suction)
 - Determination depending on the wind zone and terrain category
- Q – Horizontal load (1.4 tons) and vertical load (about 20 tons) from demolition equipment

Buckling

Load combination 1: $P = 1.0 \cdot G + 1.5 \cdot W^e + 1.0 \cdot W^i + Q$

Load combination 2: $P = 1.35 \cdot G + 1.5 \cdot W^e + 1.0 \cdot W^i + Q$

Ultimate limit state

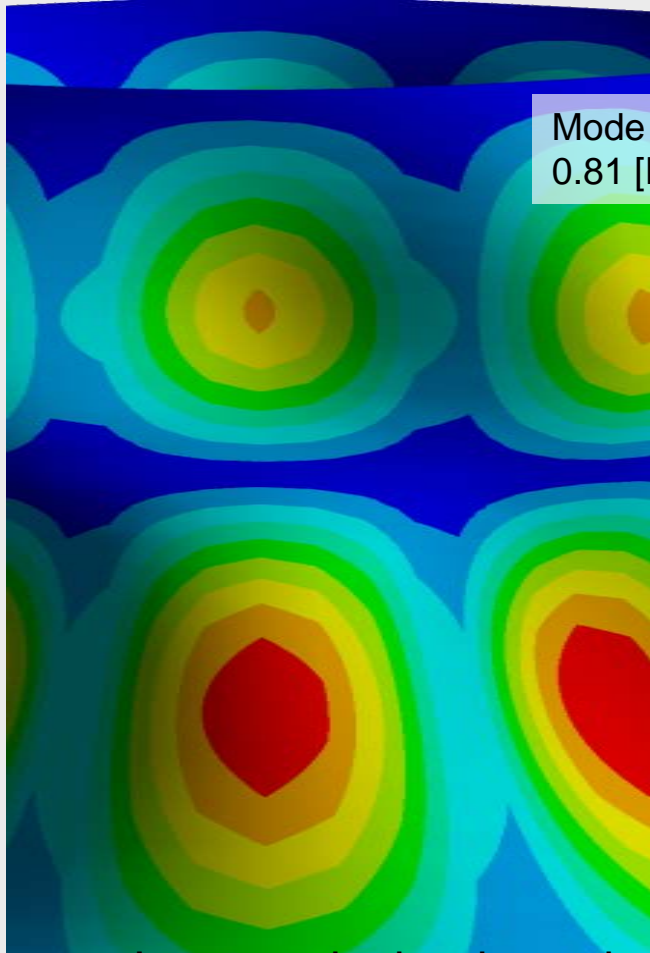
Load combination 3: $P = 1.0 \cdot G + 1.5 \cdot W^e + 1.0 \cdot W^i + Q$

Load combination 4: $P = 1.0 \cdot G + 1.5 \cdot W^e + 0.0 \cdot W^i + Q$

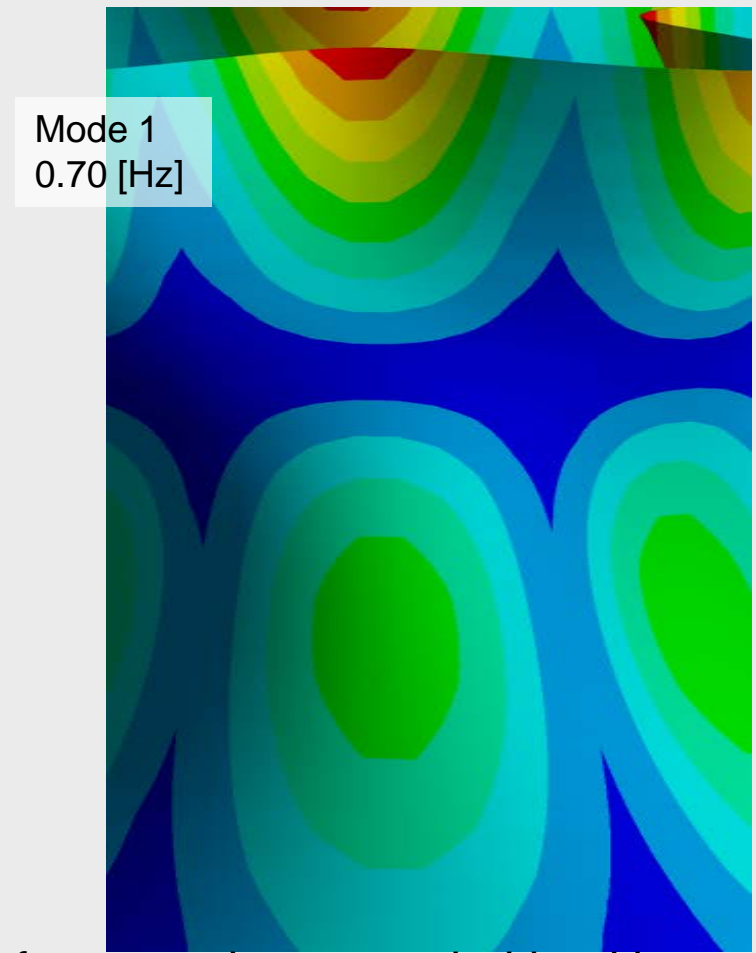
GLOBAL ANALYSIS

Natural frequency – Cooling tower

With upper edge member



Without upper edge member

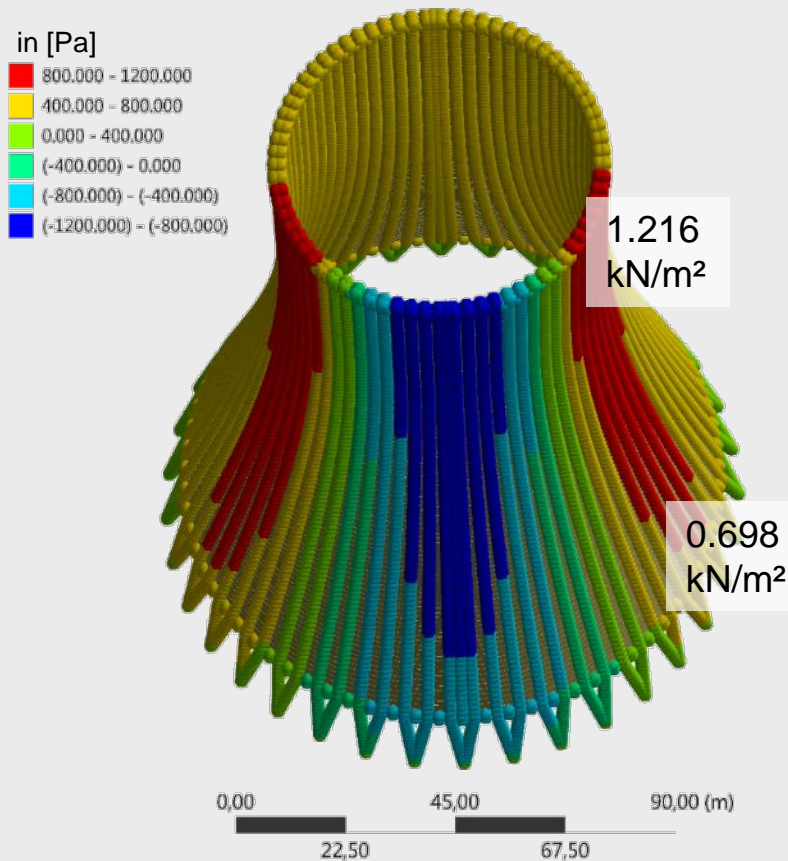


Increase in the dynamic enhancement factor on the outer wind load by approximately 5% in the *softer* structure

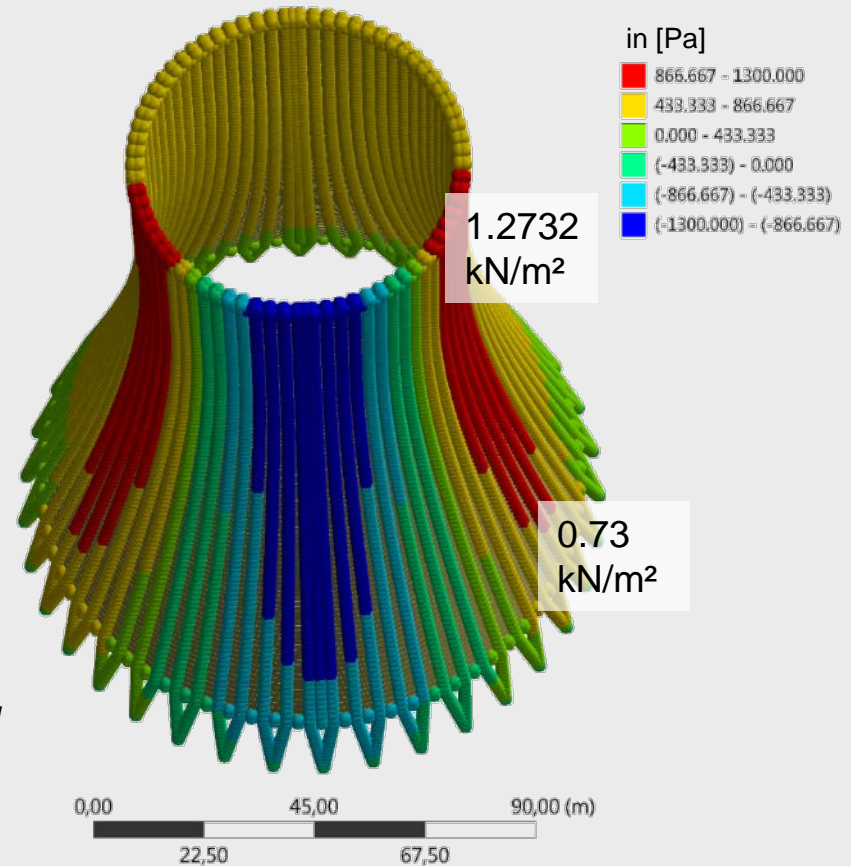
GLOBAL ANALYSIS

External wind load

With upper edge member



Without upper edge member



with $q = 0.7 \cdot q$

Consideration of permissible reduction of velocity pressure q to 70% for a 24-month-long state of construction according to the VDI regulation

GLOBAL ANALYSIS

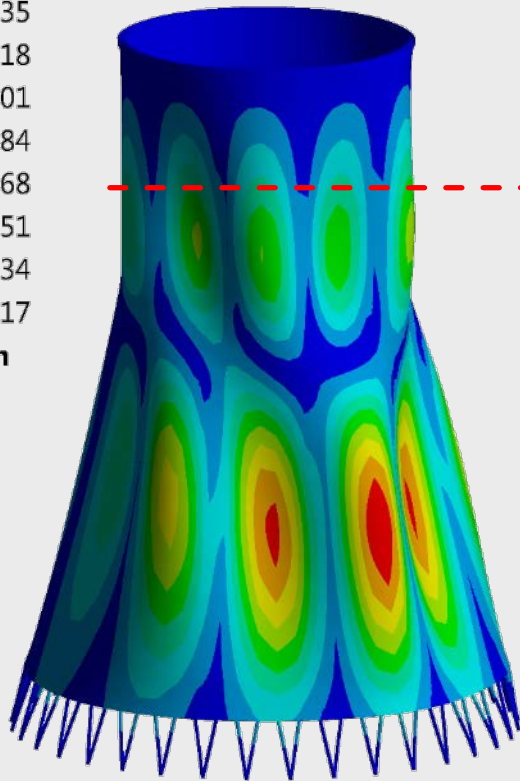
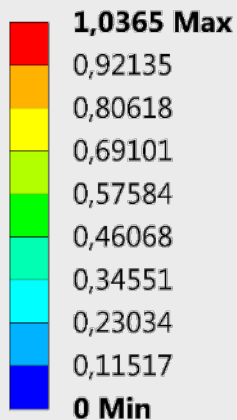
Overall safety against buckling is virtually identical

Critical load value $\sim 8 \gg 5$ (safety factor for buckling)

With upper edge member

Deformation
in [mm]

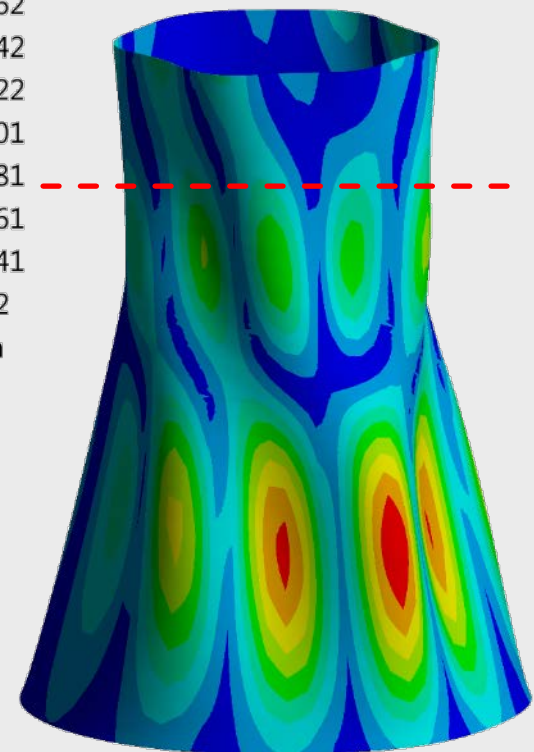
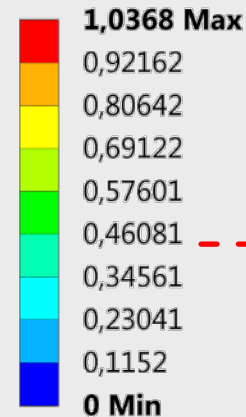
Critical load value
8.0042



Without upper edge member

Deformation
in [mm]

Critical load value
7,9555



GLOBAL ANALYSIS

Forces and moments in ring direction for $P = 1.0 \cdot G + 1.5 \cdot W^e + 0.0 \cdot W^i + Q$

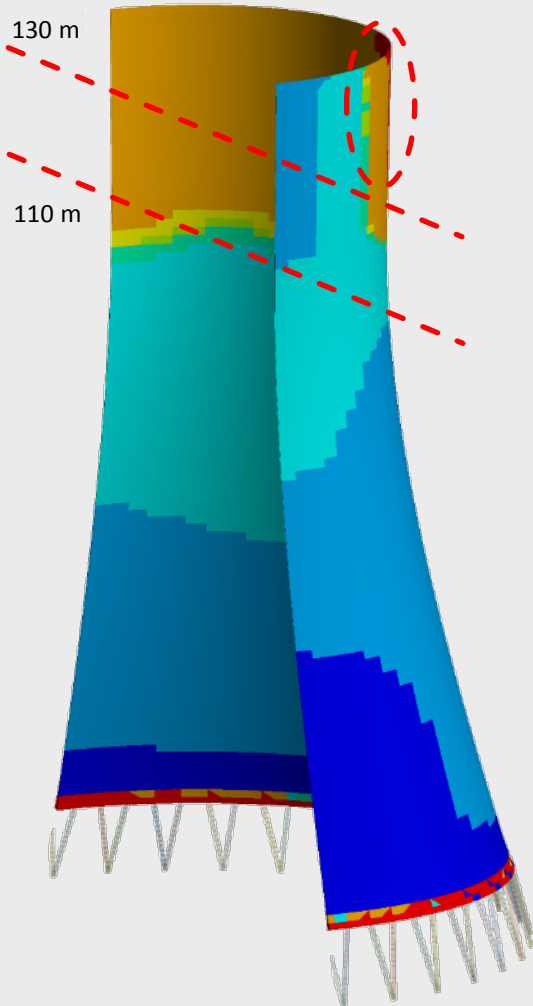
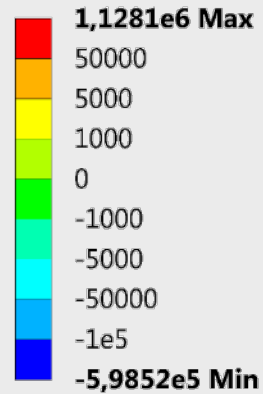
N11

J: $1.0 \cdot G + 1.5 \cdot W^e + 0.0 \cdot W^i$

N11 in [N]

Ausdruck: smisc1

Zeit: 1



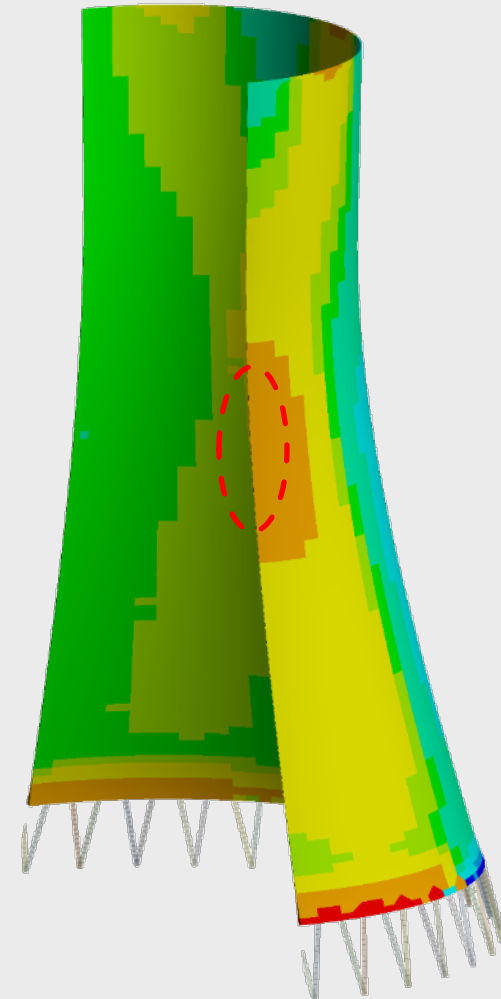
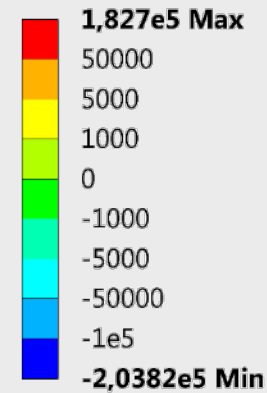
M11

J: $1.0 \cdot G + 1.5 \cdot W^e + 0.0 \cdot W^i$

M11 in [Nm]

Ausdruck: smisc4

Zeit: 1



GLOBAL ANALYSIS

Forces and moments in meridian direction for $P = 1.0 \cdot G + 1.5 \cdot W^e + 0.0 \cdot W^i + Q$

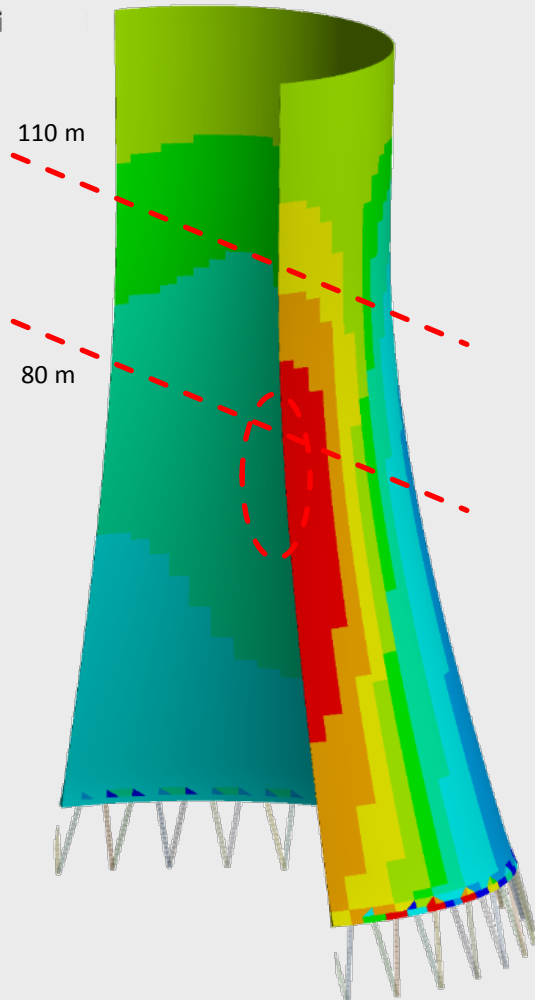
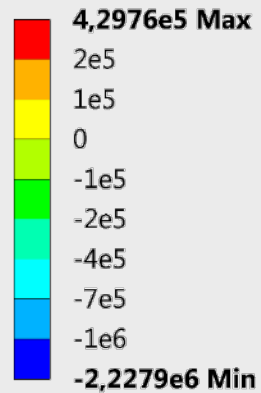
N22

J: 1.0*G + 1.5*We + 0.0*Wi

N22 in [N]

Ausdruck: smisc2

Zeit: 1



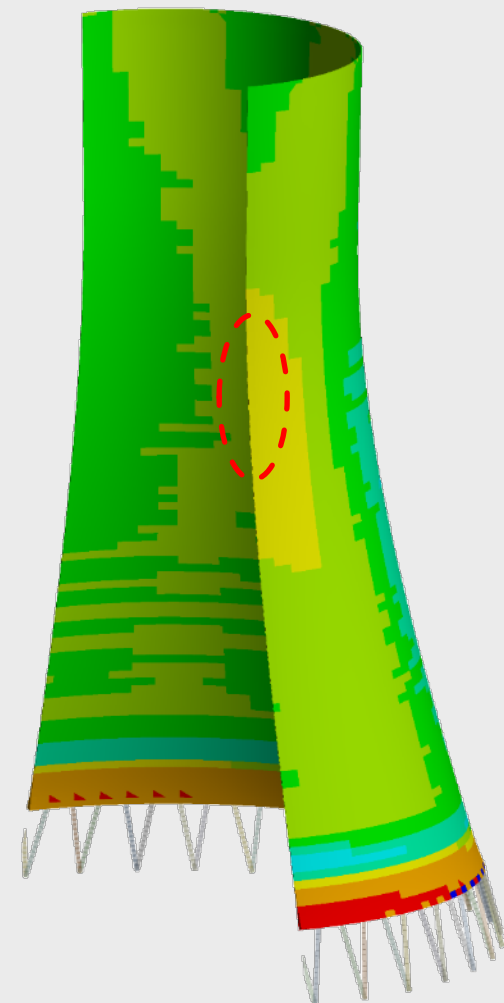
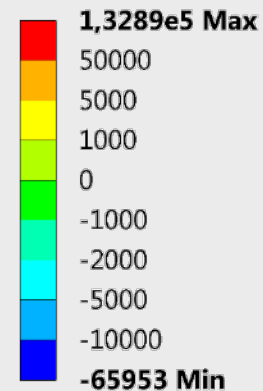
M22

J: 1.0*G + 1.5*We + 0.0*Wi

M22 in [Nm]

Ausdruck: smisc5

Zeit: 1

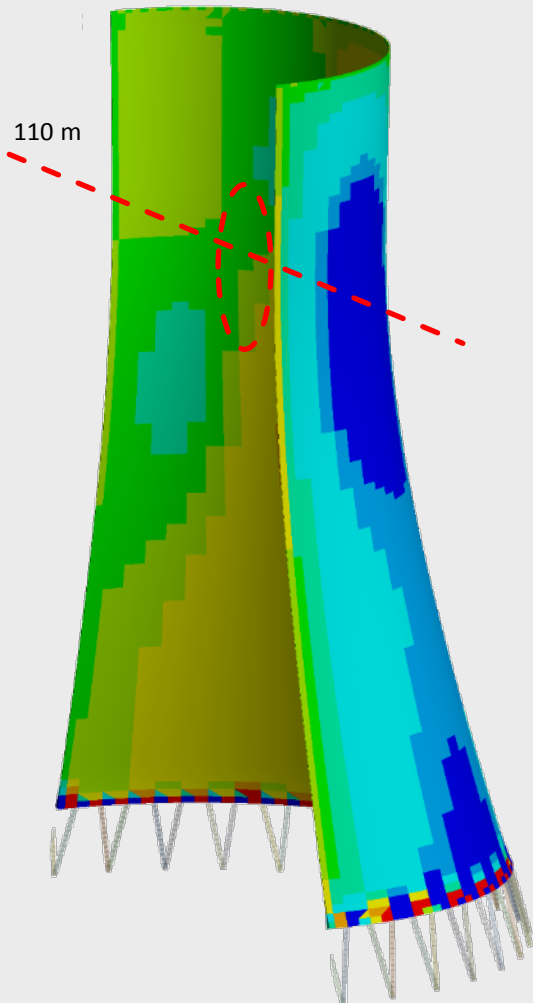
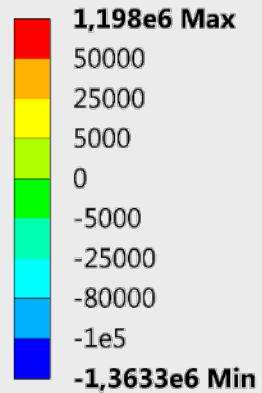


GLOBAL ANALYSIS

Shear forces and moments for $P = 1.0 \cdot G + 1.5 \cdot W^e + 0.0 \cdot W^i + Q$

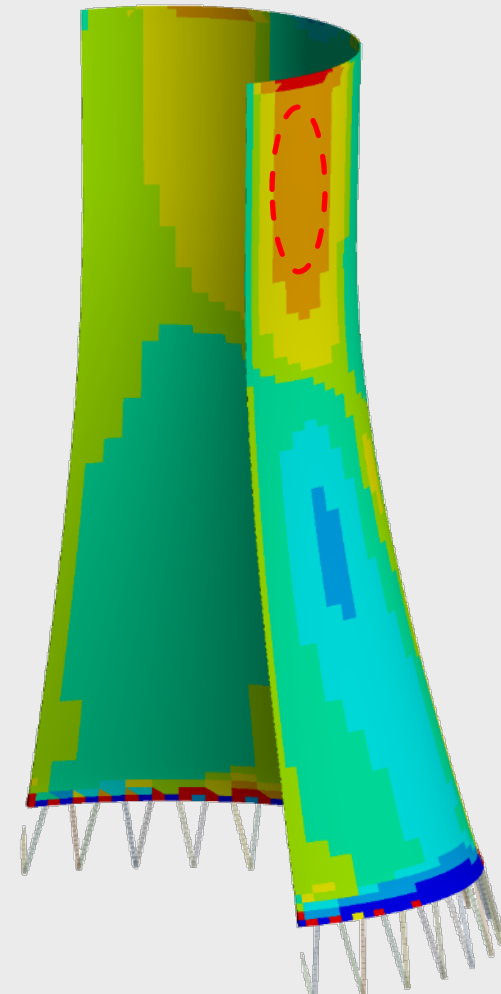
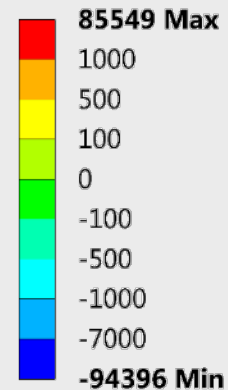
N12

J: $1.0 \cdot G + 1.5 \cdot W^e + 0.0 \cdot W^i$
N12 in [N]
Ausdruck: smisc3
Zeit: 1



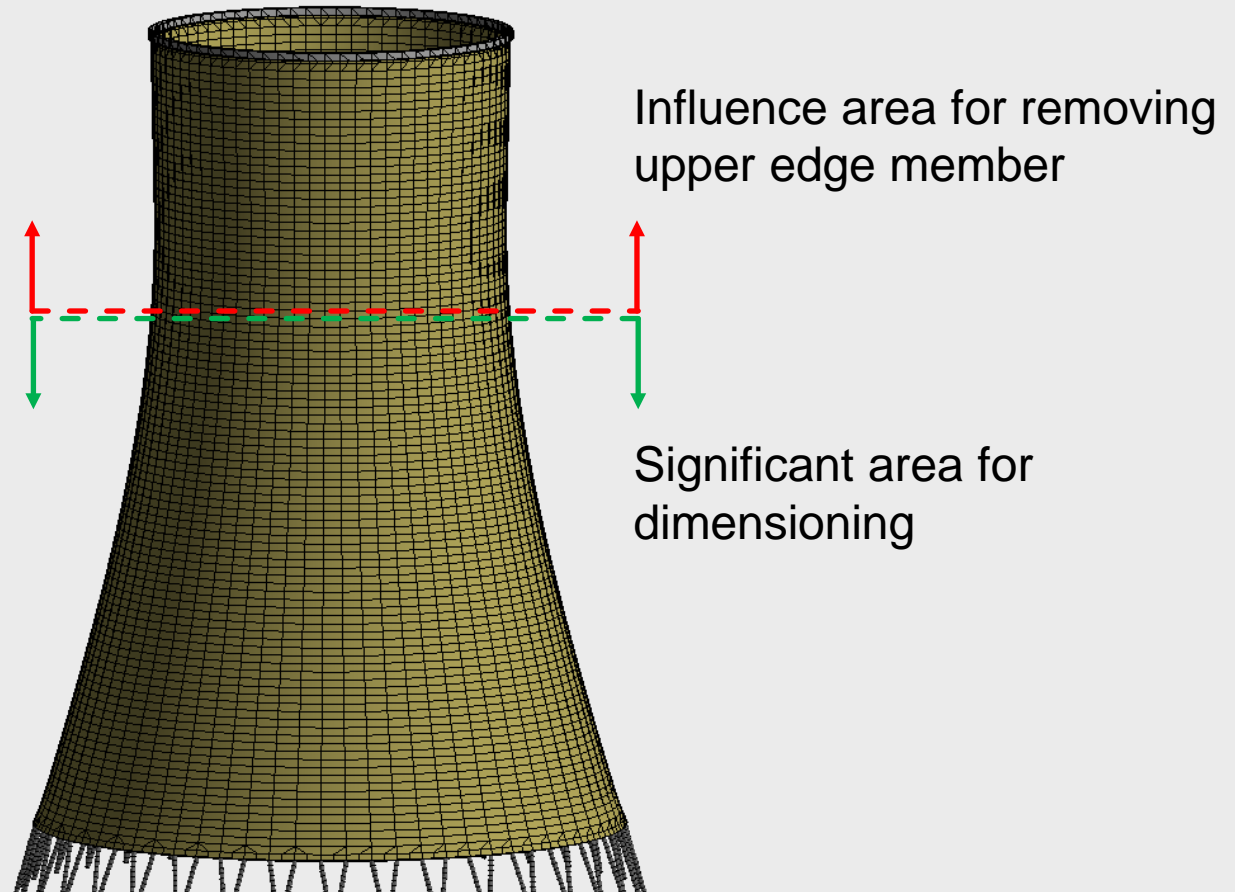
M12

J: $1.0 \cdot G + 1.5 \cdot W^e + 0.0 \cdot W^i$
M12 in [Nm]
Ausdruck: smisc6
Zeit: 1



GLOBAL ANALYSIS

Conclusions



- The cooling tower is stable for the intended controlled demolition using demolition equipment from top to bottom
- The absence of the upper edge member has no significant influence

LOCAL ANALYSIS

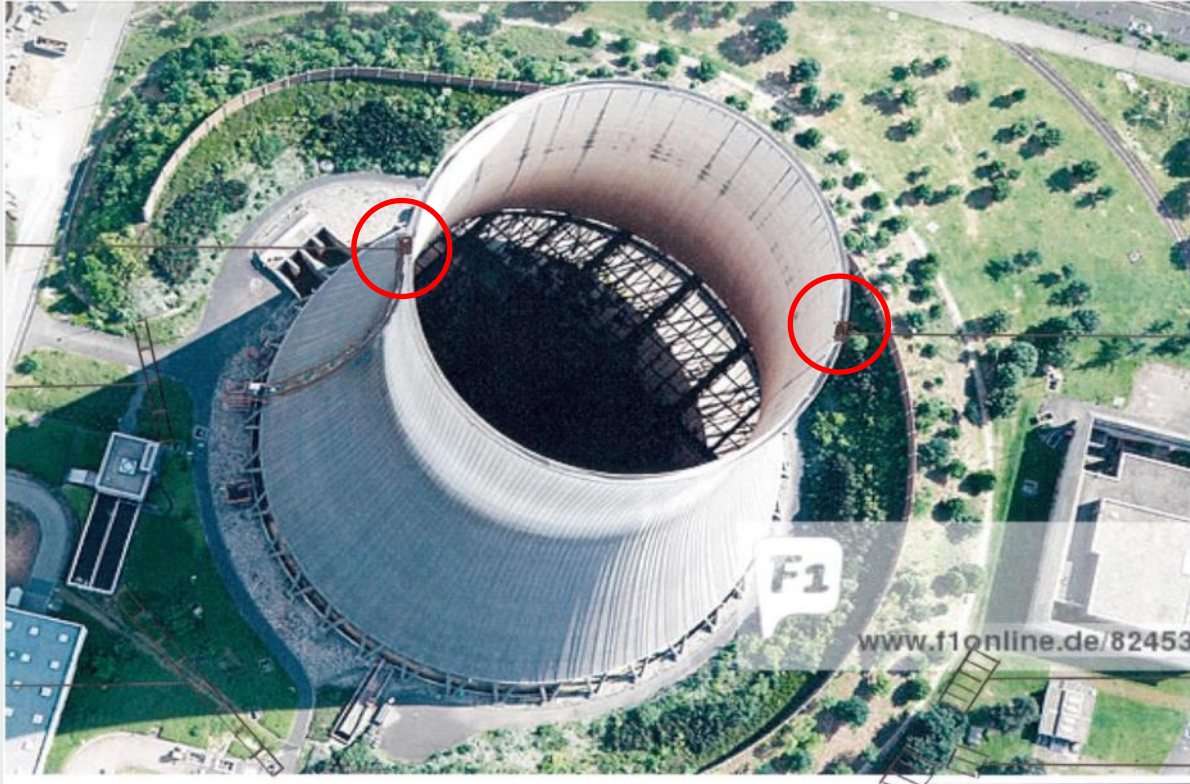
Access



Safe and quick height access
for personnel and material
provided by rack and pinion hoists

LOCAL ANALYSIS

Access



2 rack and pinion hoists to

- operate the demolition machine via radio control
- overhaul the demolition machine

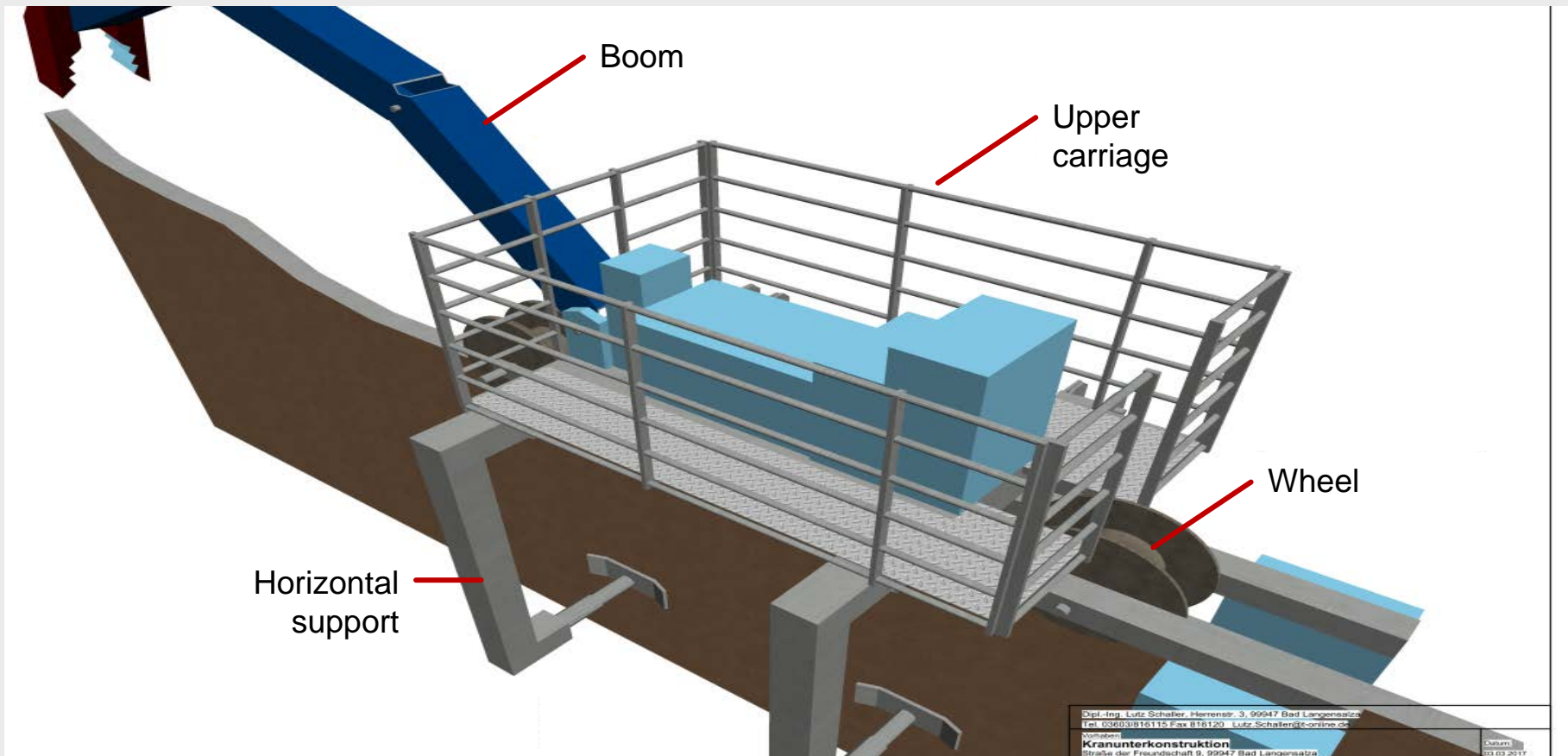
LOCAL ANALYSIS

Demolition machine - Basis



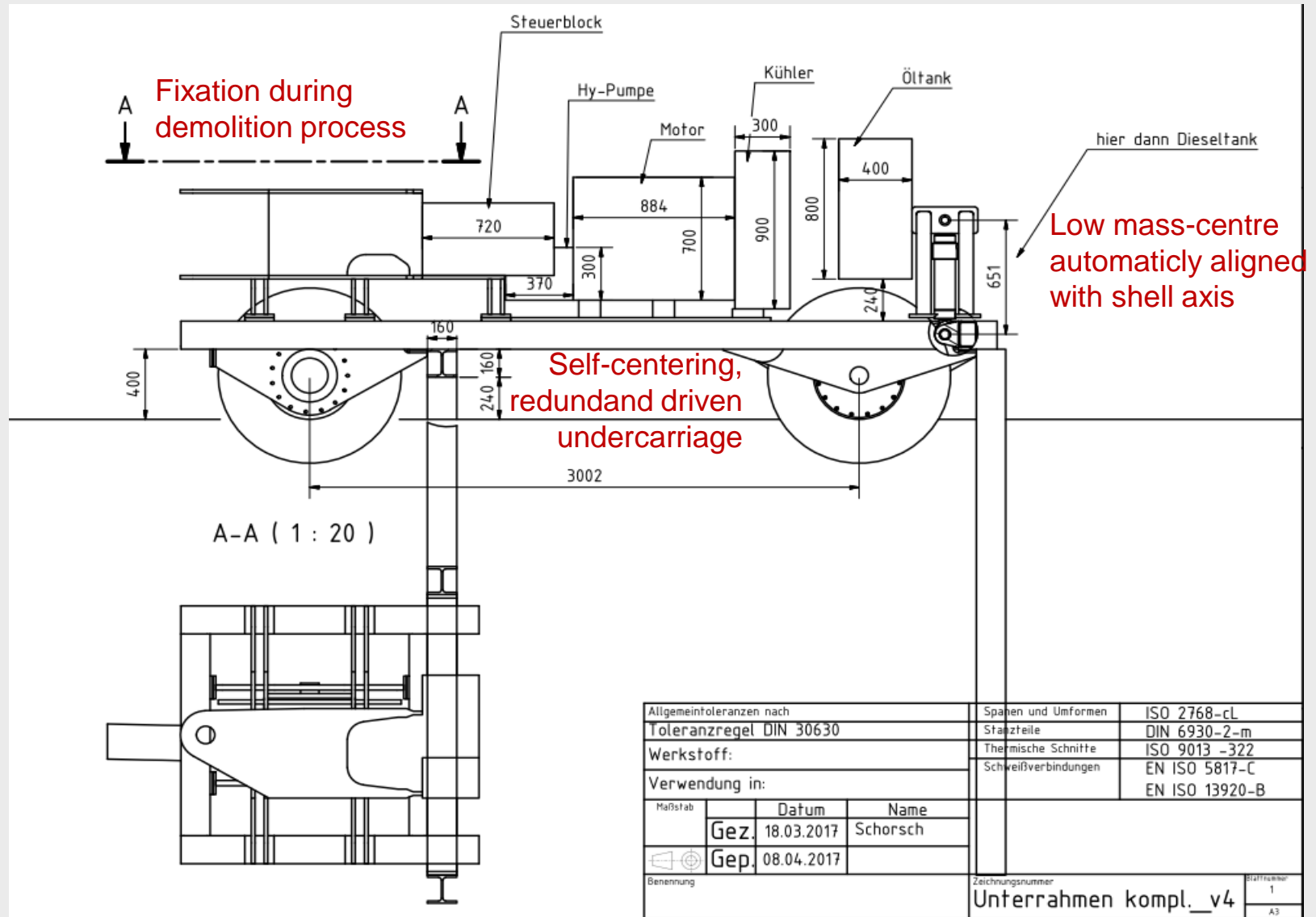
LOCAL ANALYSIS

Demolition machine - Concept



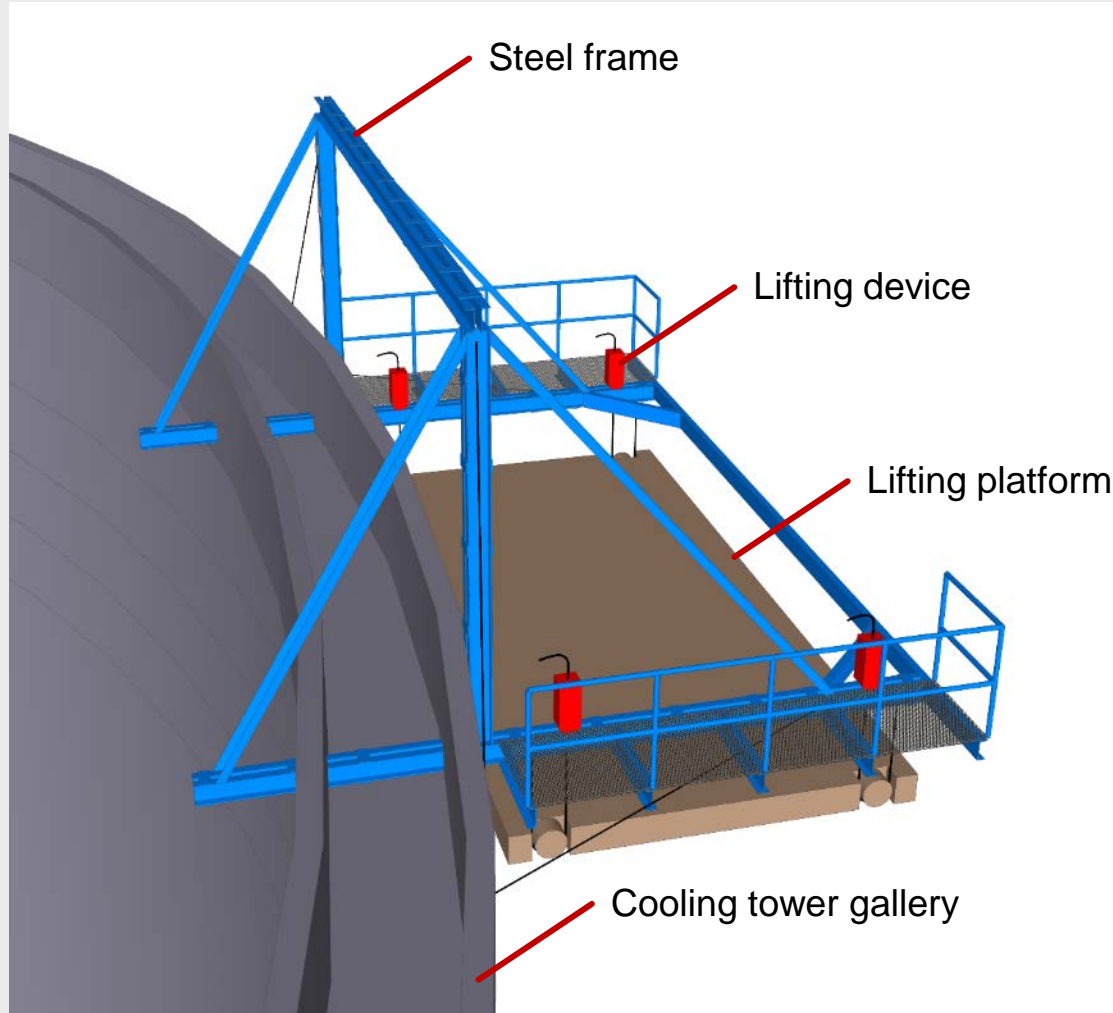
LOCAL ANALYSIS

Demolition machine - Concept



LOCAL ANALYSIS

Transportation platform



TIME SCHEDULE

Terminplanung Rückbau KT												
	Begin	Ende	Jun 17	Jul 17	Aug 17	Sep 17	Okt 17	Nov 17	Dez 17	Jan. bis März 18	April 18 bis Juli 18	Aug 18 und Folge-monate
Start site equipment	01.06.2017	28.07.2017										
Installation demolition machine	01.07.2017	28.07.2017										
Start operation	01.08.2017	30.10.2017										
Potential interruption by bad weather	01.11.2017	30.03.2018										
Weather-dependend performance	01.11.2017	30.03.2018										
Restart after bad weather period	01.04.2018	Folgemonate										
Demolition of misc. structures	01.08.2018	Folgemonate										

Späteste Wiederaufnahme
der Arbeiten zum April 18

*When the demolition starts in summer 2017 the shell will be removed until spring 2018.
Bad weather can delay the demolition process.
The demolition of the columns and the basin will take another 3 months.*

OUTLOOK

A cooling tower needs not to be blasted!

In case of strong restrictions a conventional demolition can be considered!

RWE and Exponent have initiated a Master Thesis at the Technical University of Dortmund to transfer the demolition concept to other cooling towers located close to operating units.



Thank you very much for your attention!



Do you have questions?