

Benefits of the C1 Wedge Connection™

C1 Wedge Connection

Patented and patents pending

C1 CONNECTIONS BV

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Bolted L-flange connections, an “HSE challenge”

Currently installation of the massive bolts or studs is at odds with HSE regulations.

- Weight of equipment and bolts/studs
- Working under suspended or hooked on loads
- Difficult to combine with floating installation.
- Connections require maintenance / inspections.



Next generation WTG's:

→ Larger rotors, **higher loads**

→ Taller towers, **higher loads**

=> But required tolerances are becoming stricter...

- Next generation WTG's are already exceeding the capacity of traditional connections.



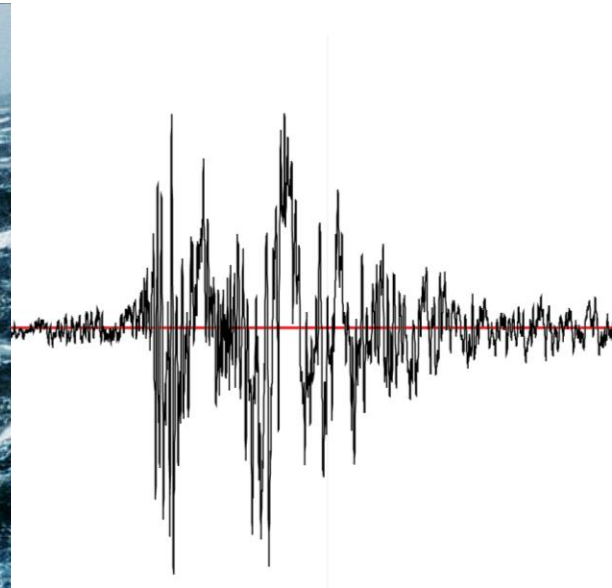
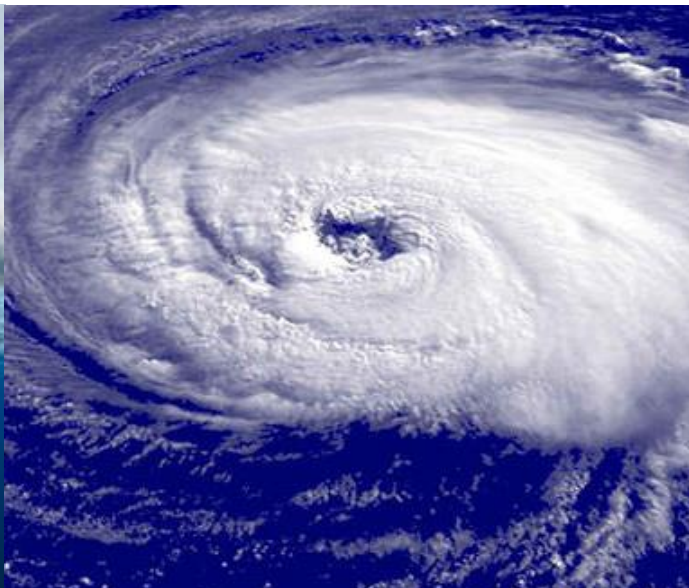
And the issue is getting worse ...

With floating foundations, and more challenging site conditions

Floating foundations often see very large overturning moments.

In many locations very challenging site conditions need to be taken into account such as:

- **Hurricanes & Typhoons**
- **Extreme Wave conditions**
- **Earthquakes**



Summing up....

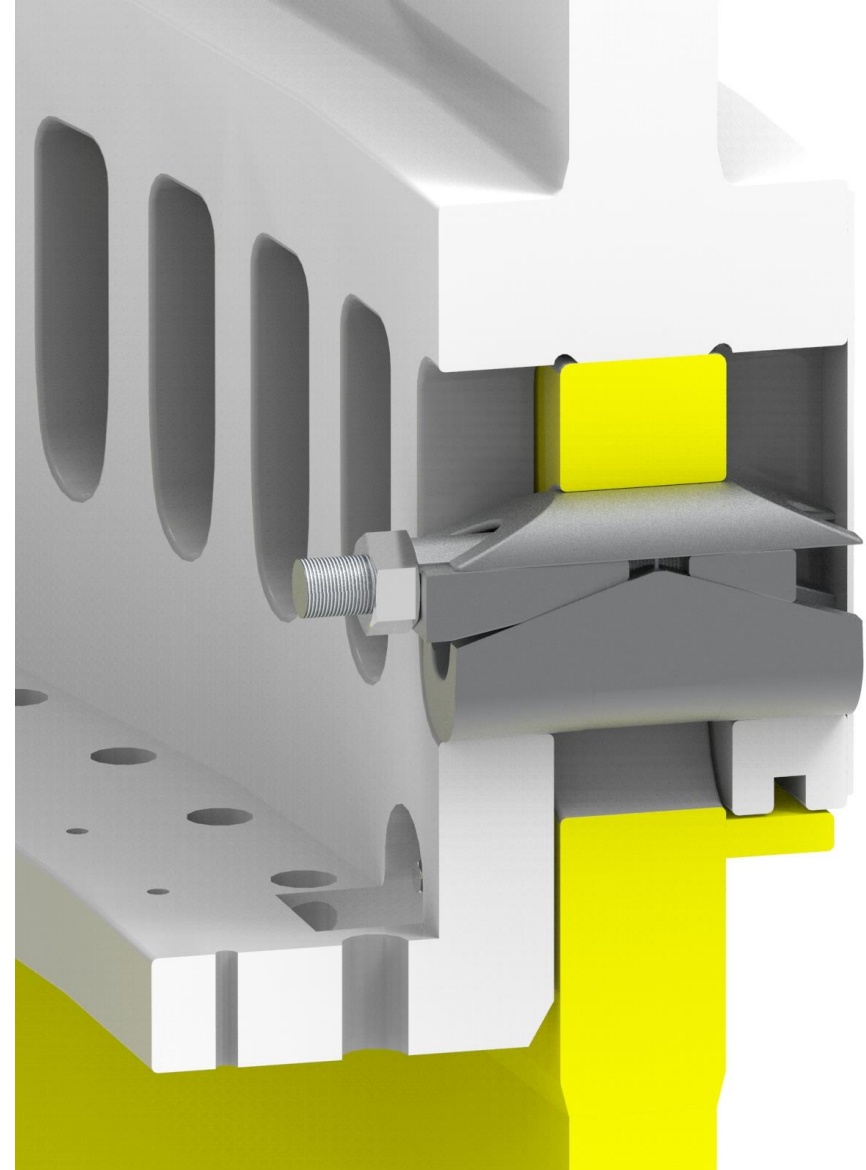
The traditional bolted L-flange has significant issues when it comes to

- **Capacity**
- **Personal Safety**
- **Maintenance**

Our solution:

The C1 Wedge Connection.

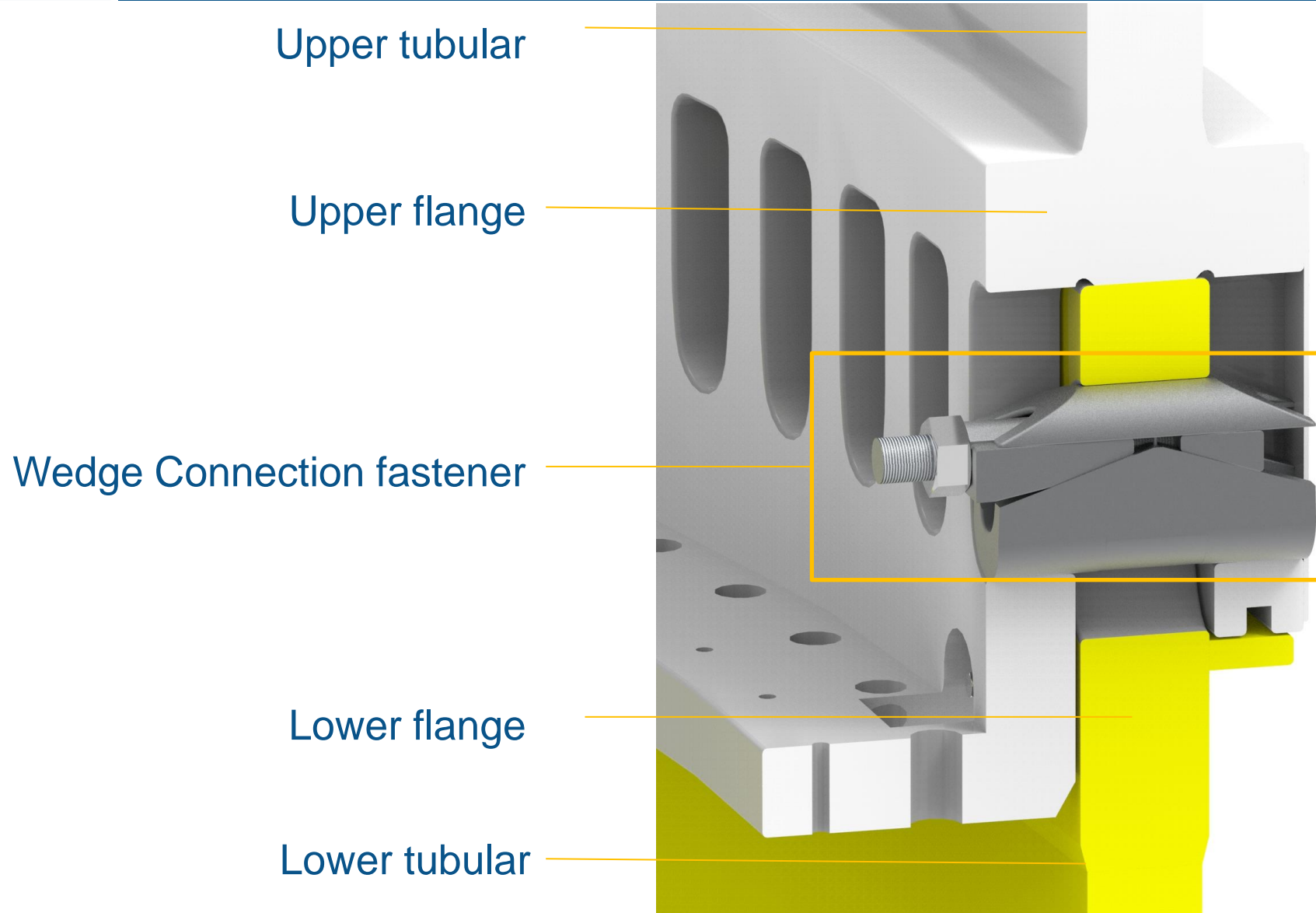
A **high ultimate capacity** and **high fatigue capacity**, **maintenance free** connection that is **safe, fast** to install.





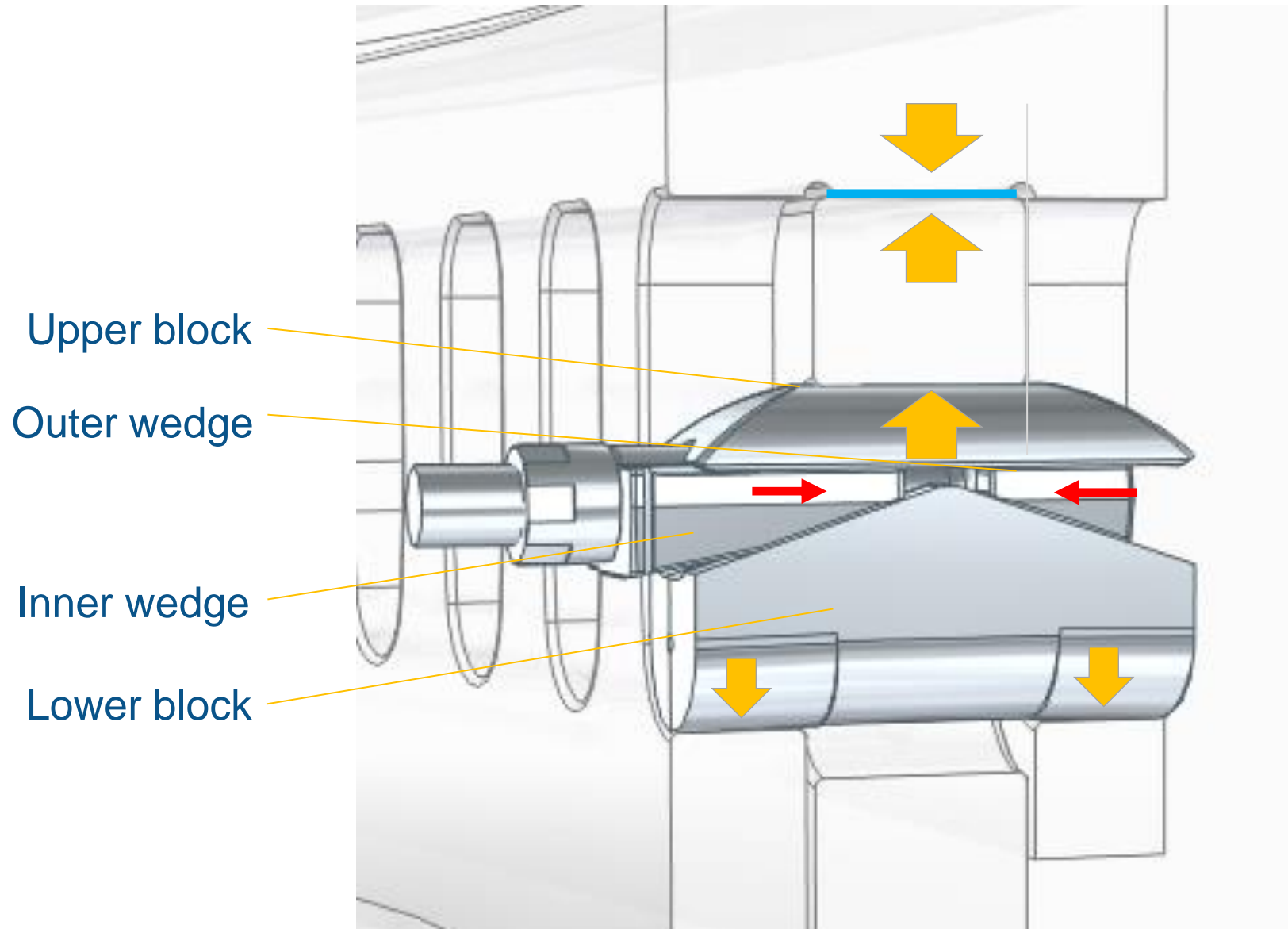
The C1 Wedge connection

General introduction



The C1 Wedge connection

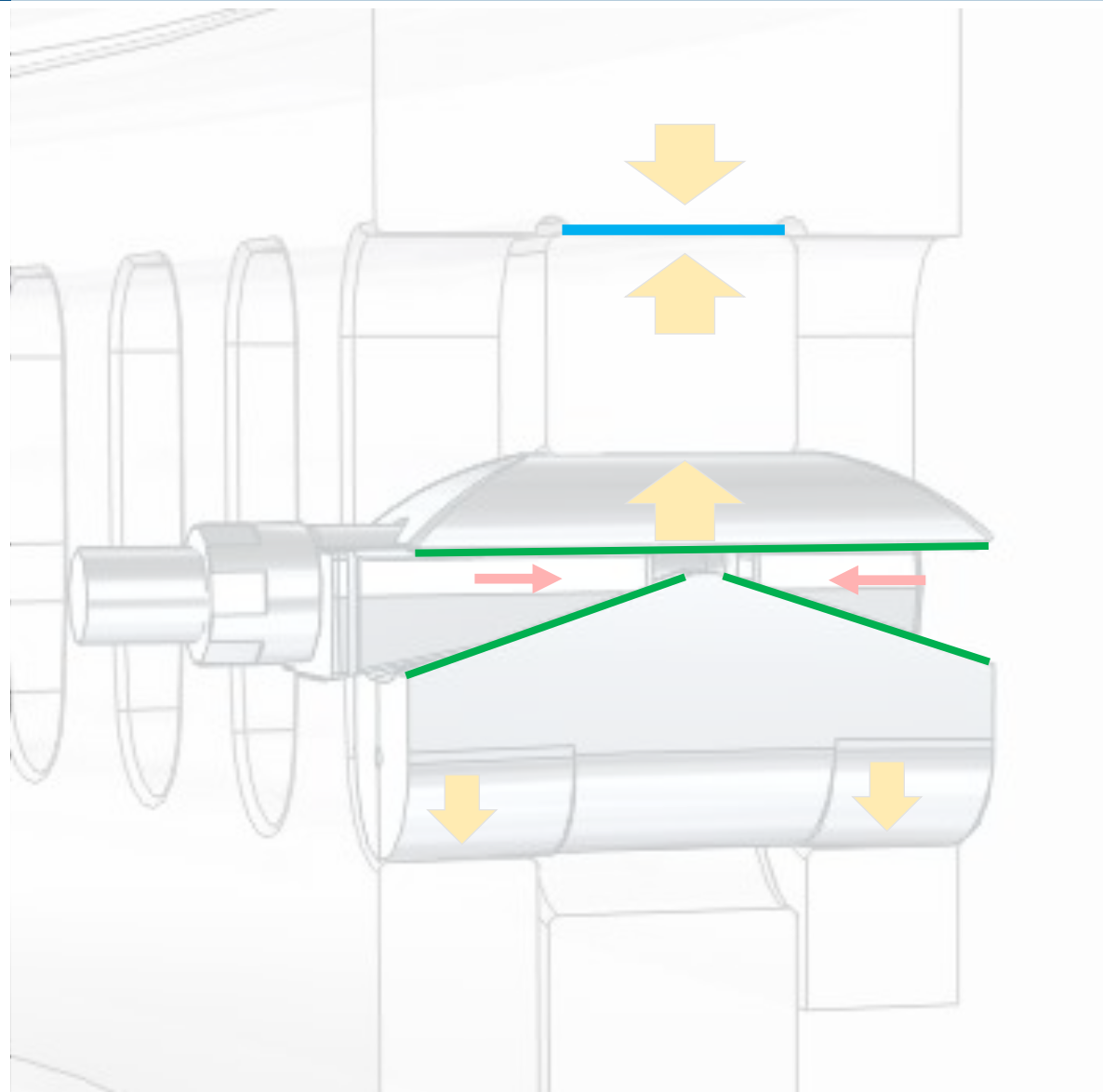
General introduction



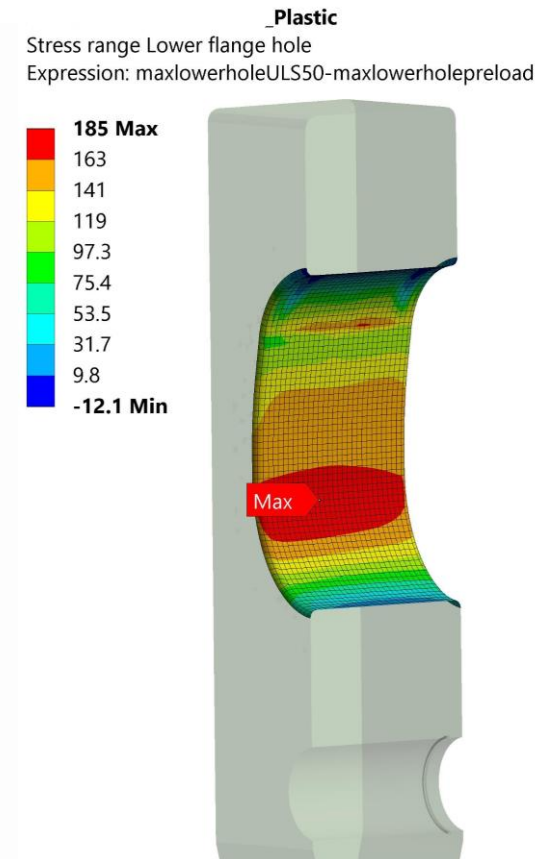
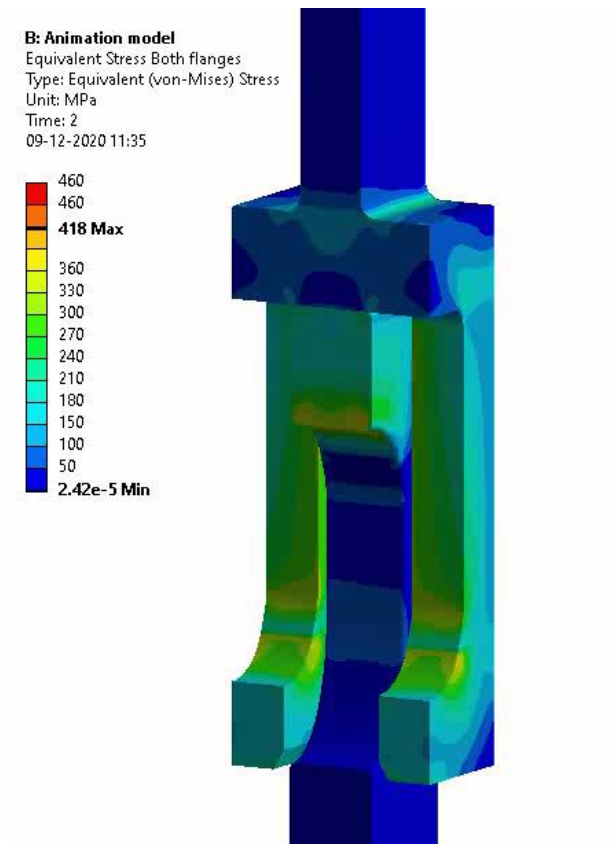
The C1 Wedge connection

General introduction

- The C1 Wedge Connection is a symmetric connection.
- The stud is mostly isolated from external loading.

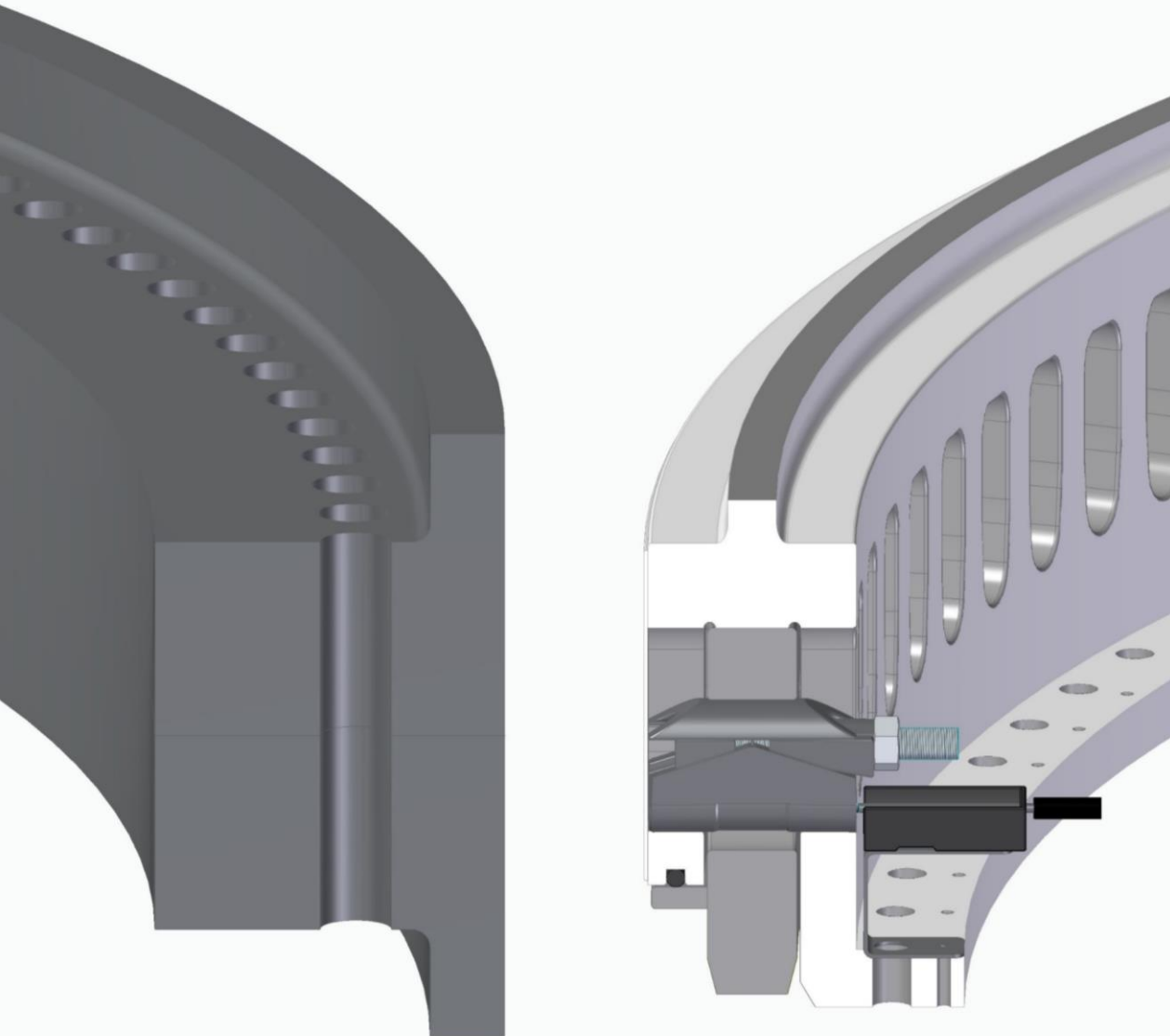


- Main load fluctuations in base material.
- Delivering **superior fatigue resistance**.
- Connection very insensitive to preload loss.
- Connection very insensitive to imperfections (waviness etc.).



Comparing next gen MP-TP and WTG-Fou connections

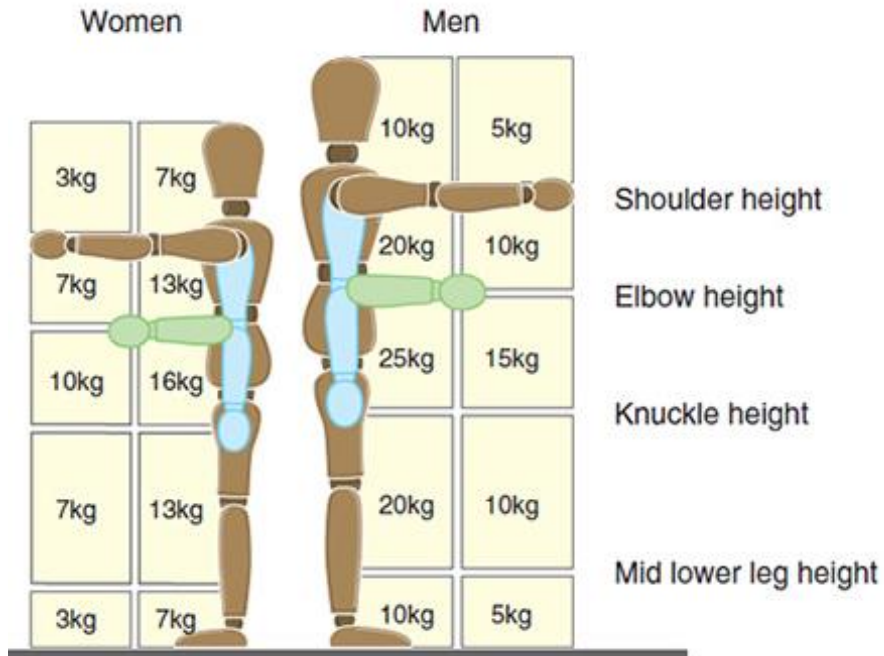
L-flange vs C1 Wedge Connection (8 meter diameter, 800 MNm)



	Bolted L-flange	C1 Wedge Connection
Total weight (flanges + fasteners)	58 mt	31 mt
Fastener size	160 x M90	120 x M42
Tool size (weight)	HEAVY	Light weight
Fatigue capacity	On / over the limit Post welding machining may be needed.	Fatigue not governing design.
Preload	Very tight preload range allowed	Up to 60-70% vertical preload drop can be accepted.
Preloading	Small rotation of the nut	Several full rotations of the nut.

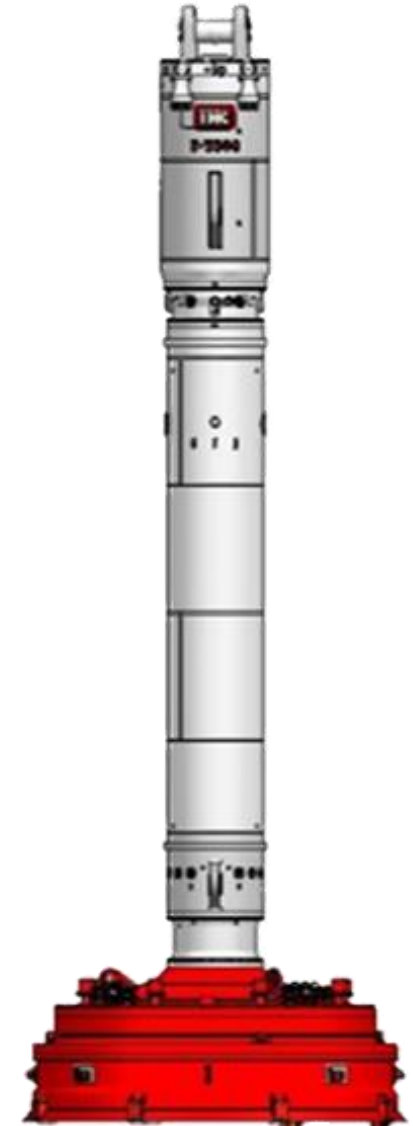
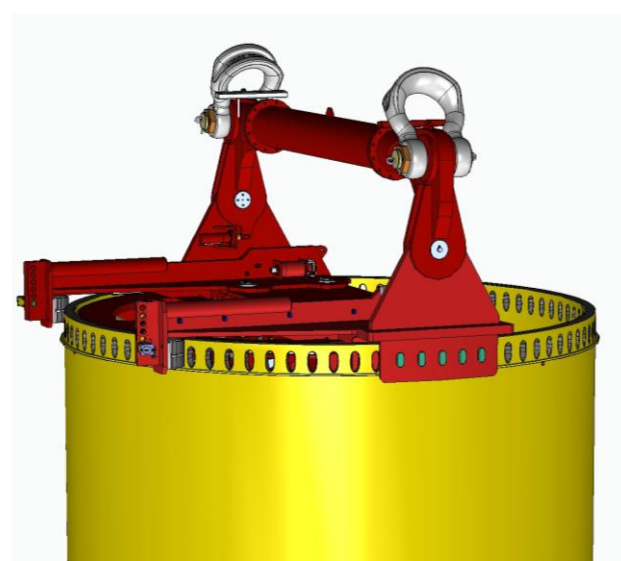
+ additional saving on secondary steel + primary steel due to absence of eccentricity and flange design

- Lightweight tools, developed together with Boltight.
- No components to be lifted
- Personnel free quick connection
- Fast installation
- Maintenance free

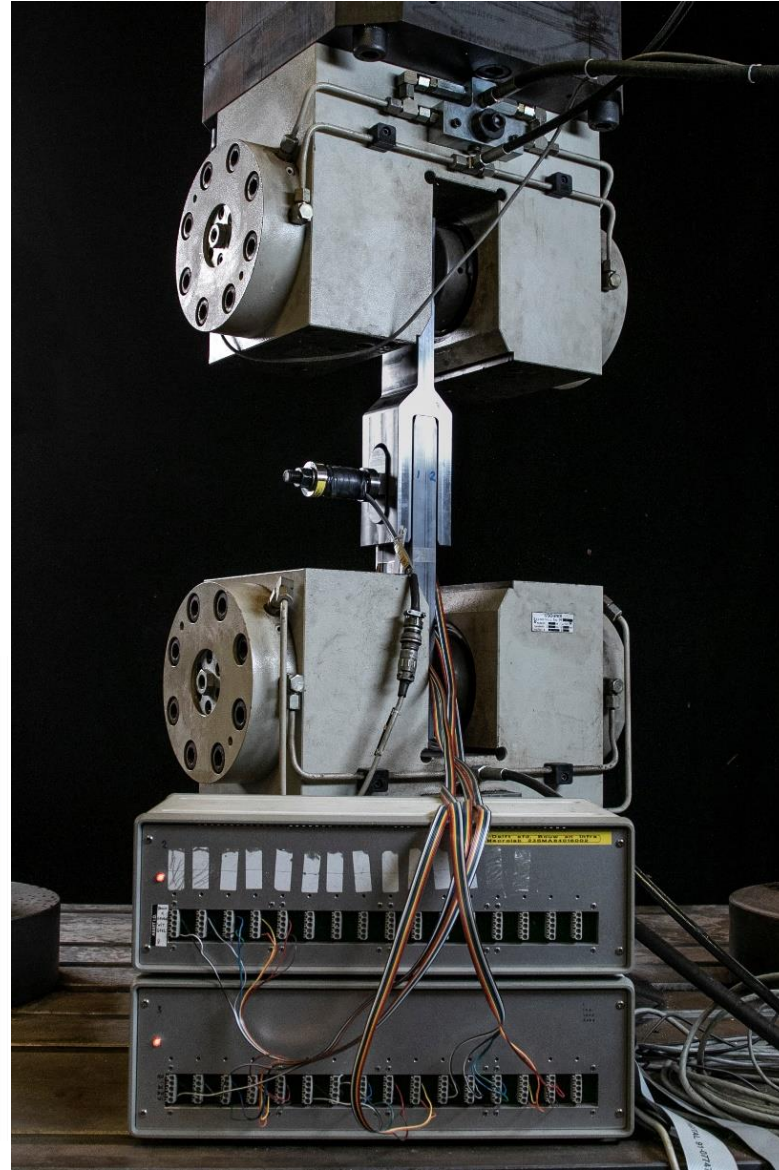


Studies show that the C1 Wedge Connection can be perfectly installed with all installation equipment:

- Impact hammers
- Vibratory hammer
- Drilling tools
- Lifting equipment



- Tested for thousands of hours
- Thoroughly modelled including misalignment and all installation and production tolerances
- DNV certified



90deg. model under ULS load including waviness with modelled gap of 3.0 [mm] @ 60°

DNV-GL

COMPONENT CERTIFICATE

Issued for:
C1 Wedge Connection – In Air
Specified in Annex 1

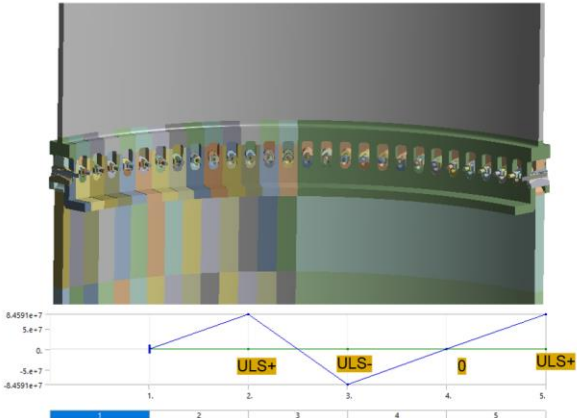
Issued for:
C1 Connections B.V.
Delftseweg 12,
2020 J.L. Oude, The Netherlands

According to:
DNVGL-SE-0441:2016-06 Type and component certification of wind turbines

Based on the documents:
AD-DNVGL-SE-0441-07030-0 A-Design Statement of Compliance, dated 2021-03-19
AT-DNVGL-SE-0441-07031-0 A-Test Statement of Compliance, dated 2021-03-19
AW-DNVGL-SE-0441-07032-0 A-Relocating Statement of Compliance, dated 2021-03-19
RCP-02-DNVGL-SE-0441-07033-0 Final Certification Report, dated 2021-03-19

Changes of the system design, the production or the manufacturer's quality system are to be approved by DNV GL.

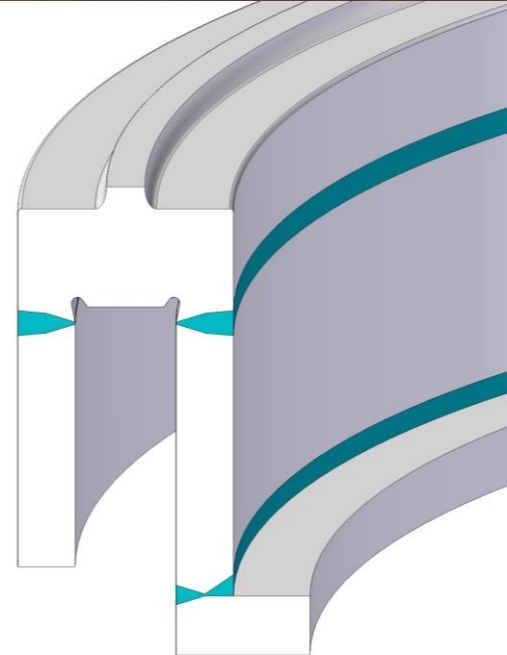
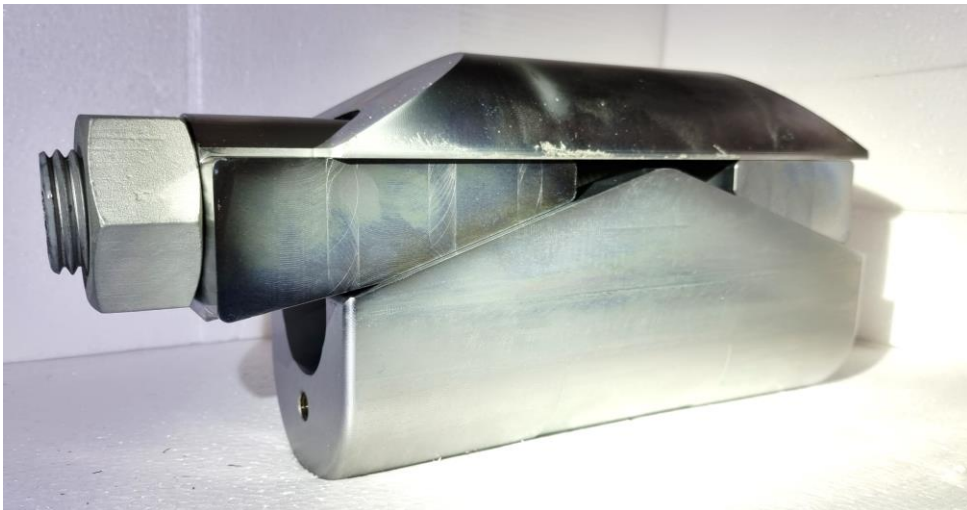
Hamburg, 2023-03-05
For DNV GL Renewable Certification
Andreas Meyer
Product Manager



Non-linear material models



- **Flanges** are supplied as turn-key flanges. Industrialization of the production is developed in collaboration with **GRI**
- Flanges can be welded to tower / MP & TP as any other flange.
- **Fasteners** are supplied by C1 Connections.
- Everybody can make the designs



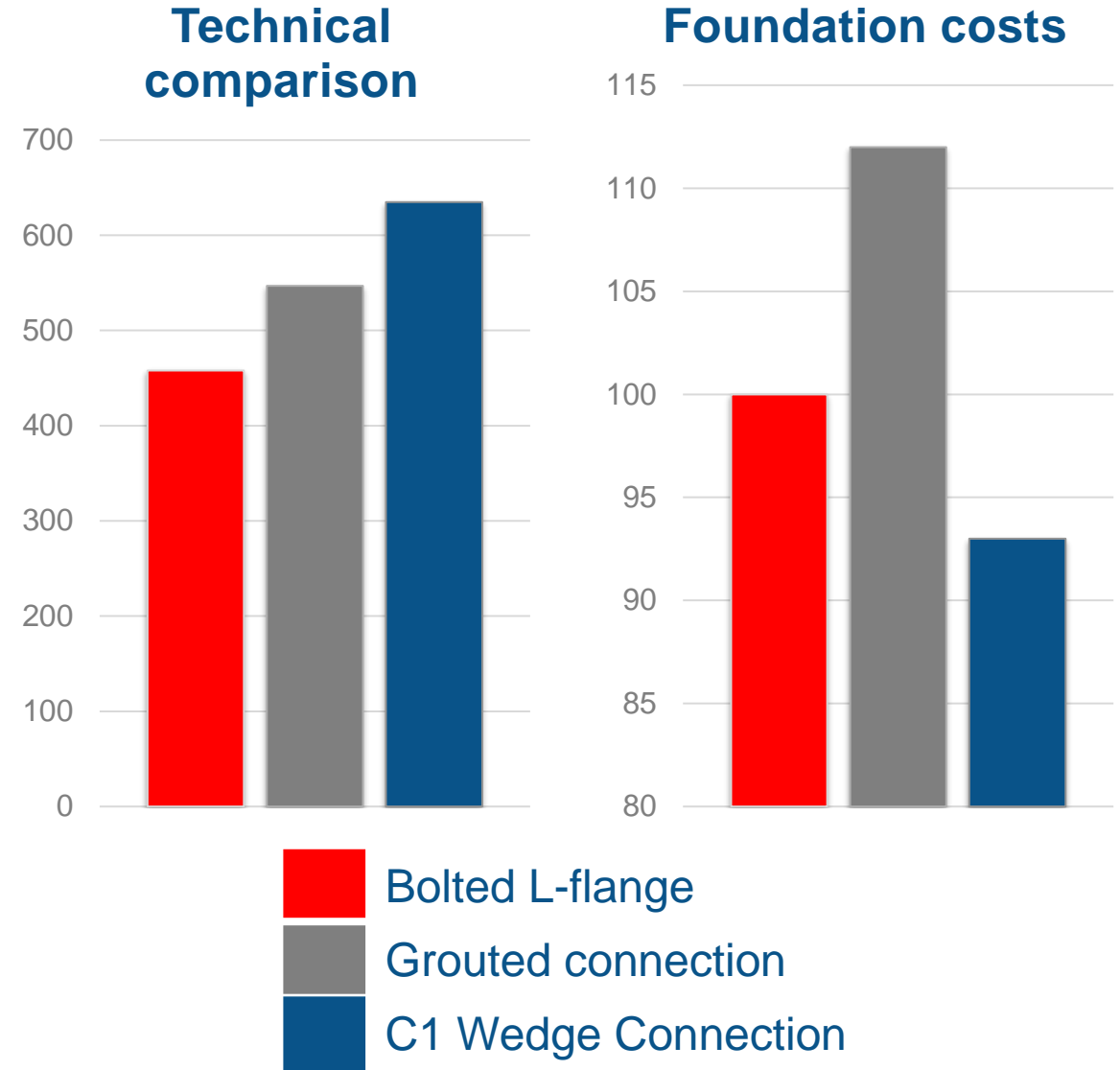
Independent review by the third party

Technically and commercially attractive solution

Independent 3rd party analysis confirms that the C1 Wedge Connection technically outperforms the bolted L-flange and grouted connection.

Compared to a bolted MP-TP connection the C1 Wedge Connection will reduce the costs of a foundation with an MP-TP connection by 7%.

Compared to a grouted connection MP-TP connection the C1 Wedge Connection will reduce the costs of a foundation with an MP-TP connection by 17%.



Foundation – tower and MP-TP connections

Benefits for clients

- Safer and faster installation
- Next generation WTG proof
- Not fatigue sensitive
- Easy and fast to design
- Low CAPEX levels
- No OPEX

How can you get the connection in your project?

C1 Connections openly shares all design and engineering knowledge with the market.

- Papers
- Design tools (V1 to be released around summer)
- Example studies
- Concept designs