Rake and drive-head design for a thickener used in the treatment of acid mine drainage: A case of displacements large and small

Roelof Minnaar

Stuttgart

12 April 2018

PERMAS
Users' Conference
Stuttgart 2018

ASM | Advanced Structural Mechanics

Acid Mine Drainage (AMD) What, Why & Where

WHAT:

- Low pH or acidic waters, caused by the oxidation of sulphide minerals

WHY:

- Abandoned underground workings fill with water
- Water exposed to vast rock surfaces containing sulphides
- At the water surface, oxygen is available from air
- Formation of acidic waters, characterised by high concentrations of salts and heavy metals

Acid Mine Drainage (AMD)

WHERE:

- Witwatersrand Gold Fields (Johannesburg)
- Mining activity started in 1886
- Continued for 120 years
- Extending over a front of 60 km
- Down to depths exceeding 3,000m below surface

1885 Benz Patent Motorwagen

But what is the problem?

- Slow flooding of the void
- Contamination of other water sources

Uncontrolled decant of AMD at 18 Winze shaft, West Rand, in March 2014 following heavy rains

The solution

Pumping

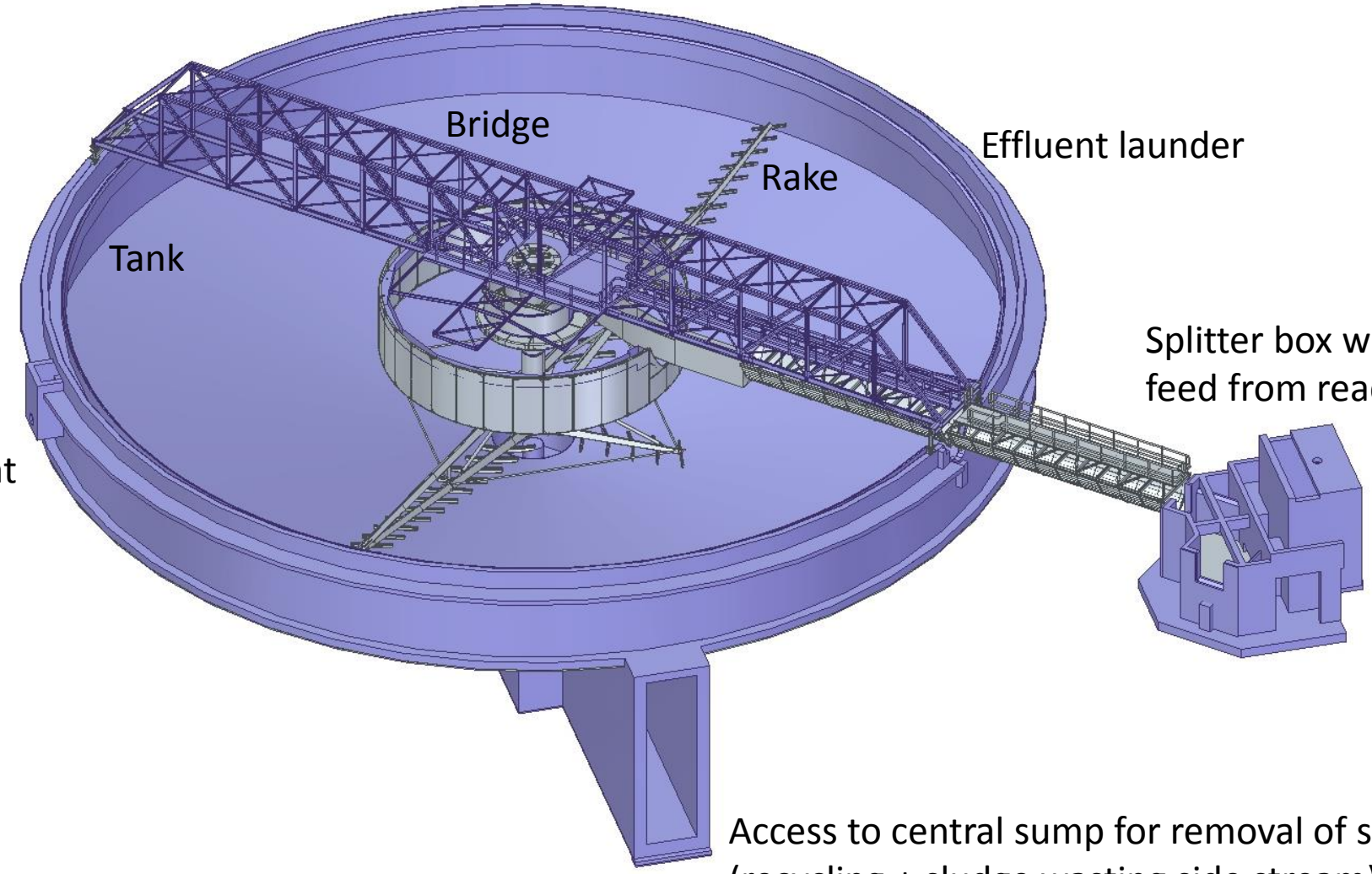
- Control level to below *"Environmentally Critical Level"* – level at which no AMD contaminates ground or surface water sources
- Three pump stations cover Witwatersrand Gold Fields, each pumping 40 – 110 Ml/day (500 – 1300 l/s)

Treatment

- Lime neutralization in a high density sludge process (HDS)
- Increase pH from 3 to 9 with lime slurry
- At this ph – metals insoluble and precipitate
- Introduce air to oxidize iron and manganese which assist their precipitation

Eastern Basin AMD Treatment Plant

Basic thickener layout



Basic dimensions & specifications

Diameter
= 47 m

Wall height
= 5 m

Depth in centre
= 8.7 m

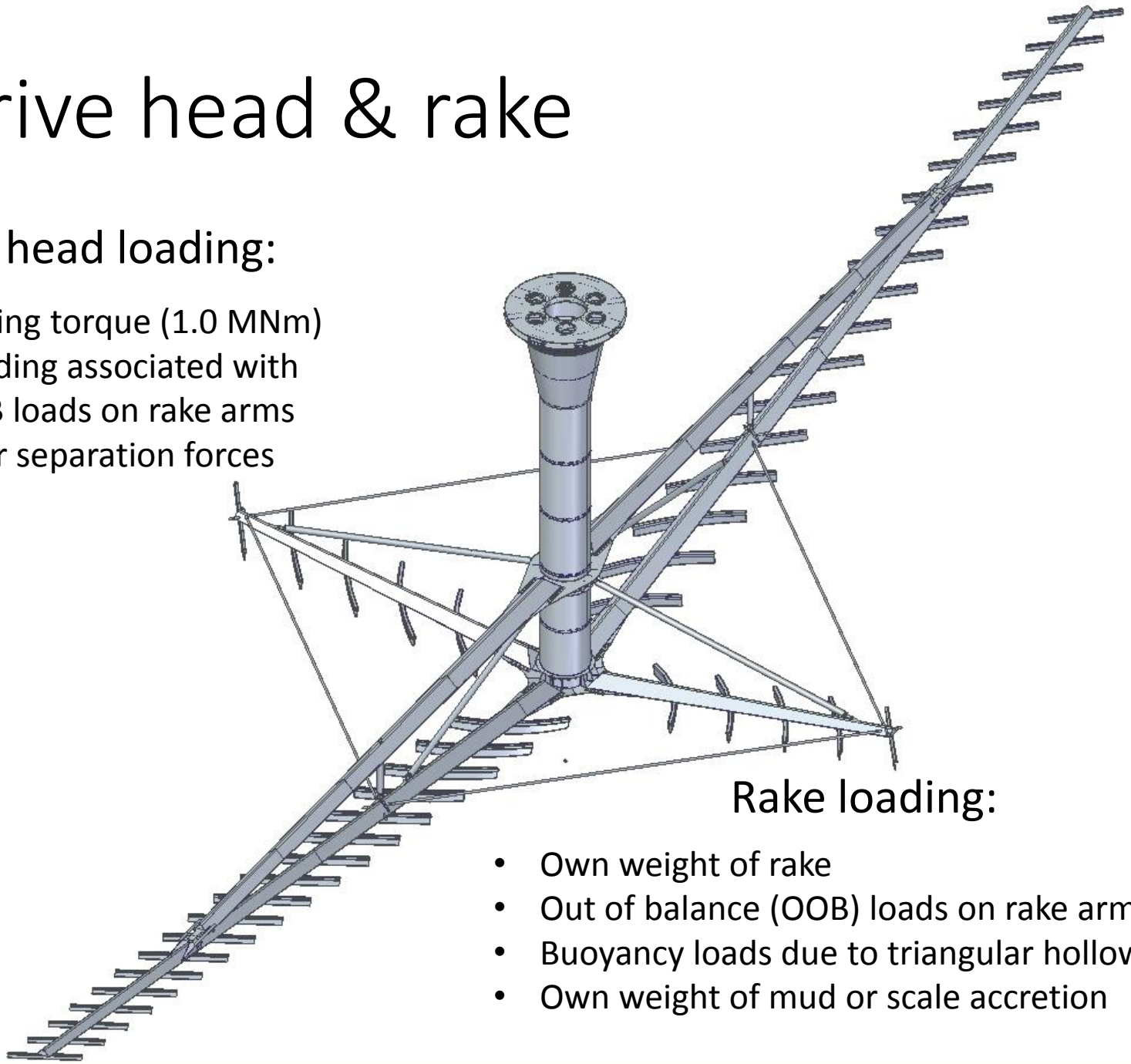
Mass of rake assembly
= 14 Tonnes

Torque provided by drive head
= 1.0 MNm

Drive head & rake

Drive head loading:

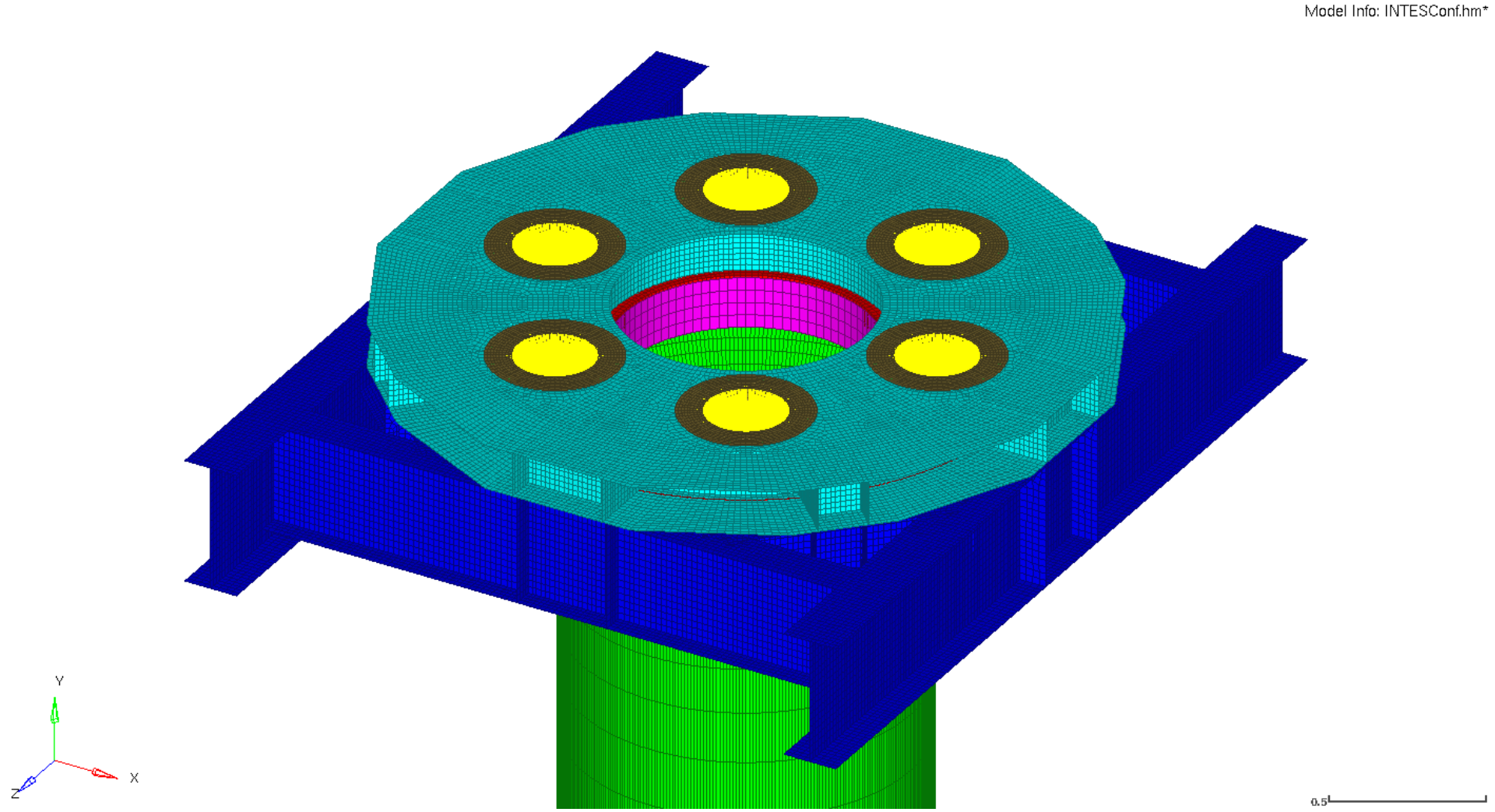
- Driving torque (1.0 MNm)
- Bending associated with OOB loads on rake arms
- Gear separation forces



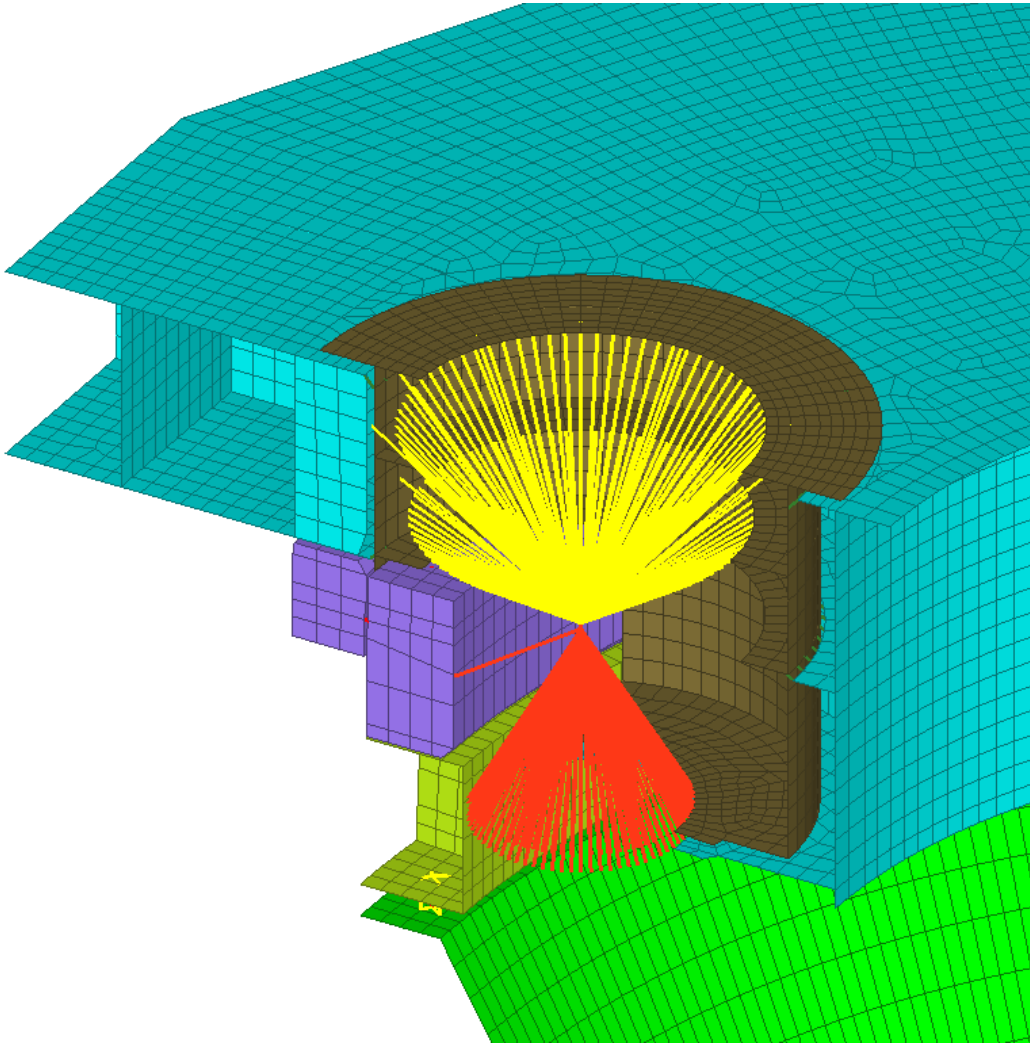
Rake loading:

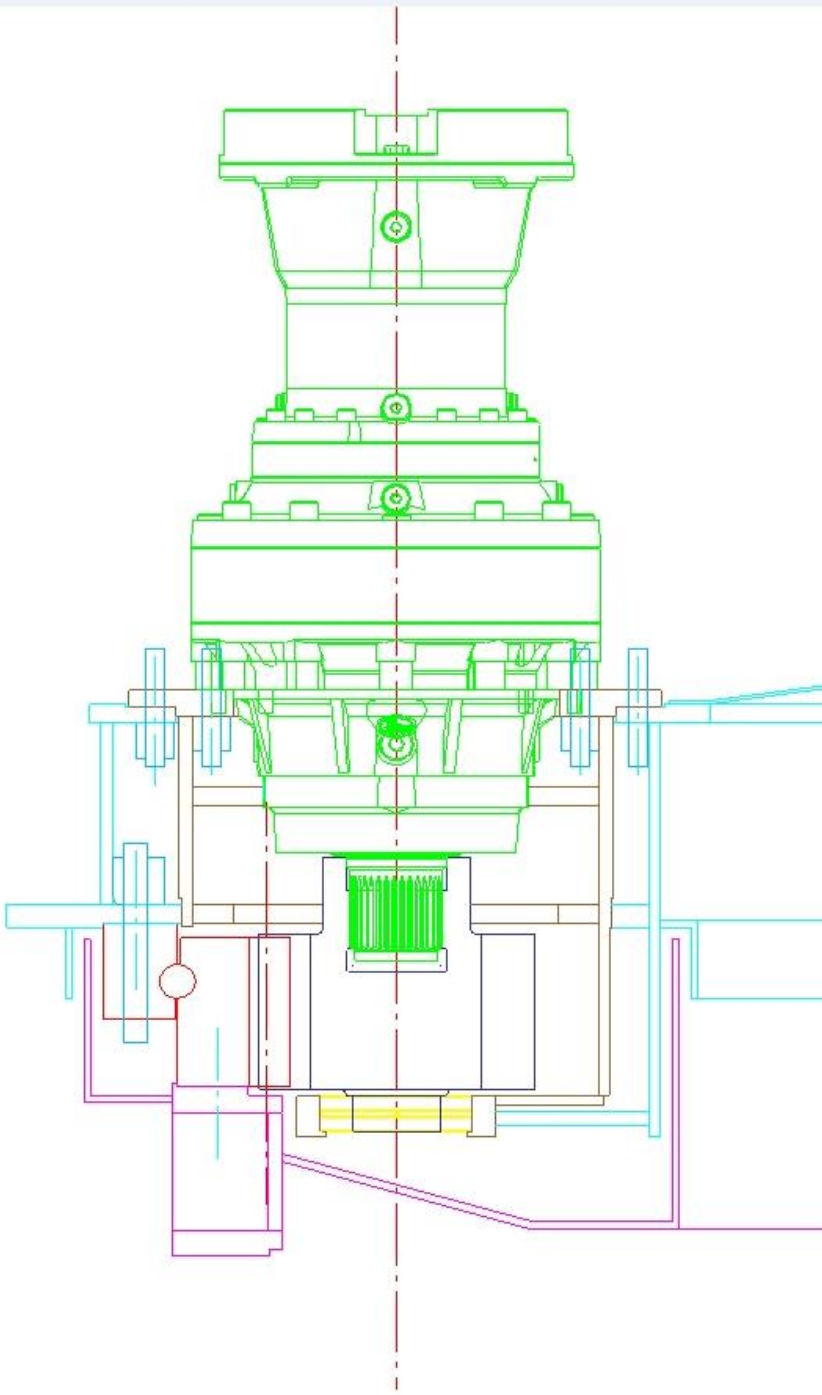
- Own weight of rake
- Out of balance (OOB) loads on rake arms 60:40
- Buoyancy loads due to triangular hollow sections
- Own weight of mud or scale accretion

Drive head

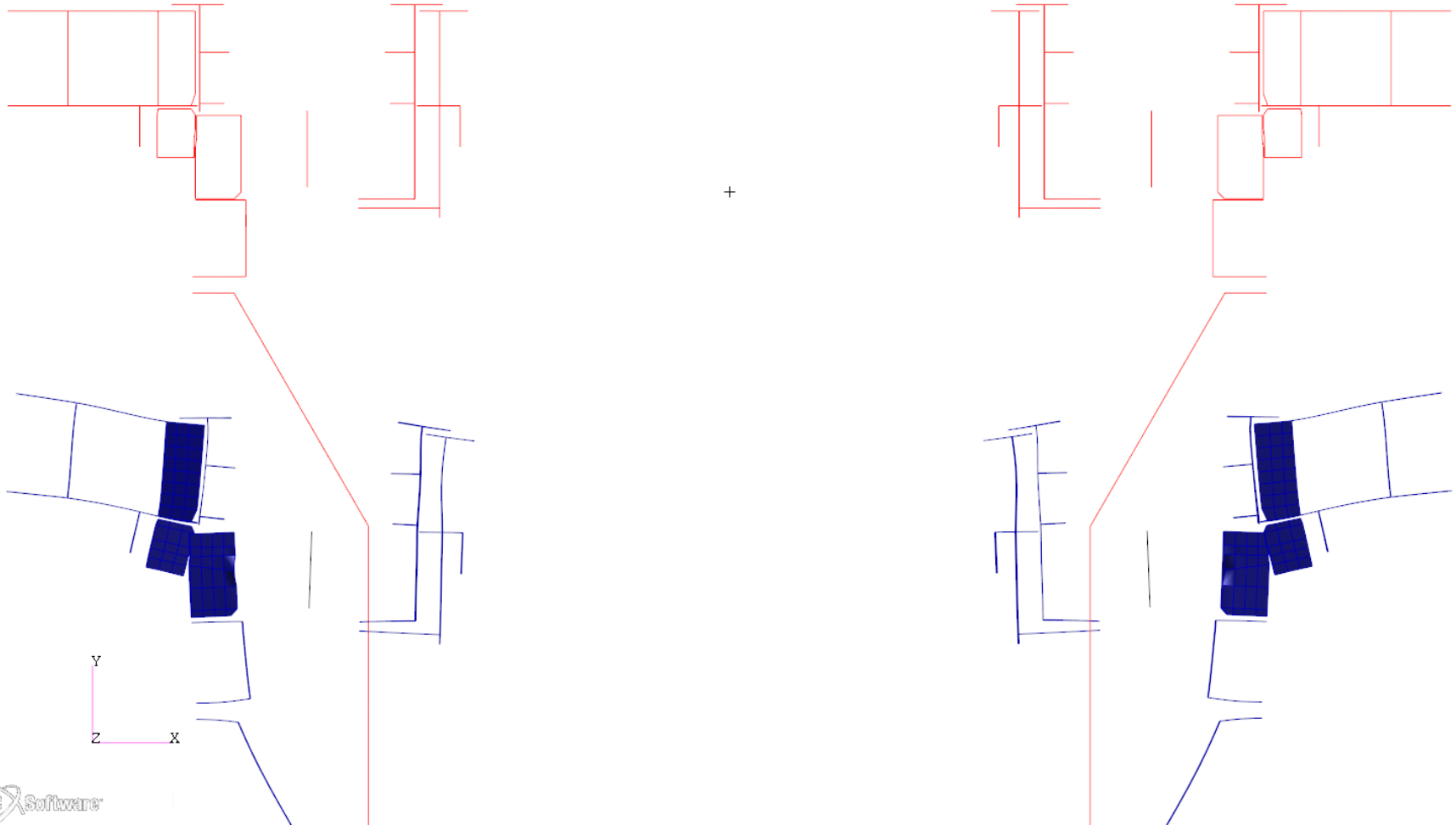


Drive head

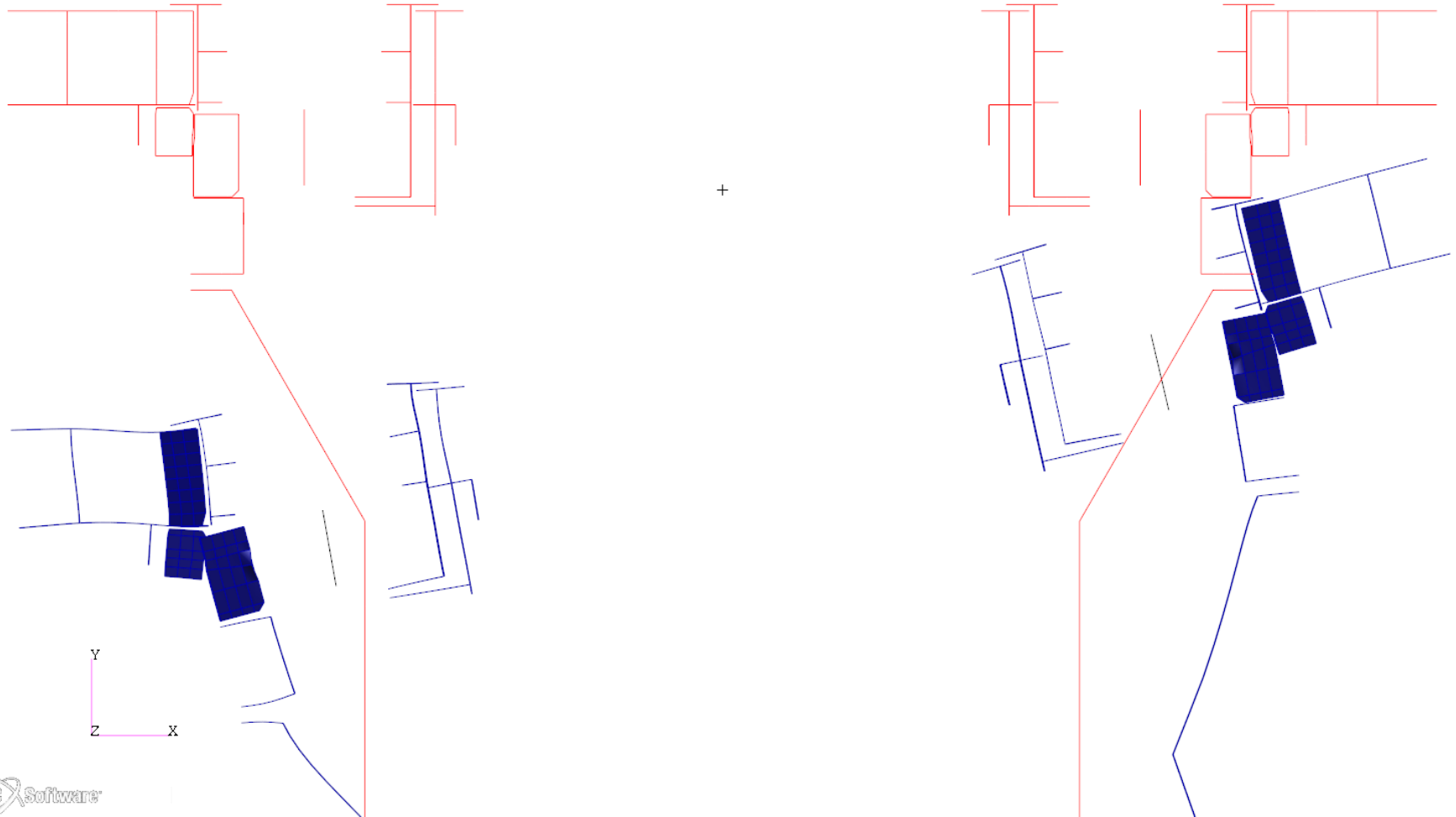




Drive head deformation (DSF = 200)
Own weight + Torque



Drive head deformation (DSF = 200)
Own weight + Torque + OOB



Slew ring distortion

Installation tolerances:

<u>Circumferential flatness</u>

<u>$\Delta a \leq 0.25$mm</u>

Inclination on radial plane

$\Delta b \leq 0.125$ mm

(measured over 100 mm)

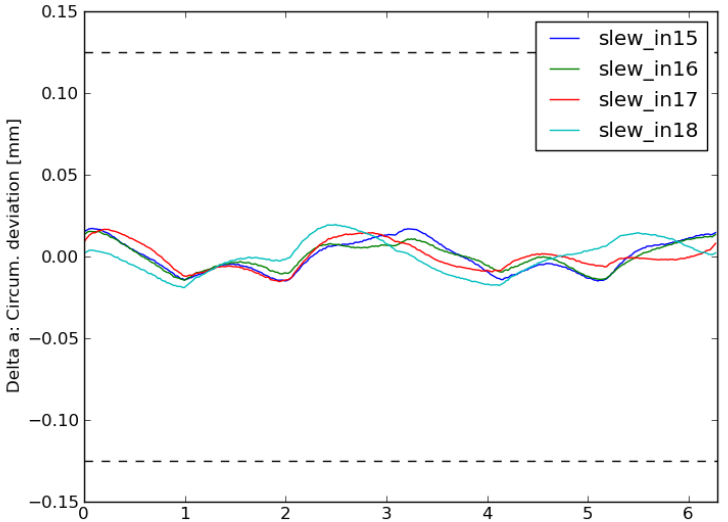
Graphs corrected for rigid body translation & rotation

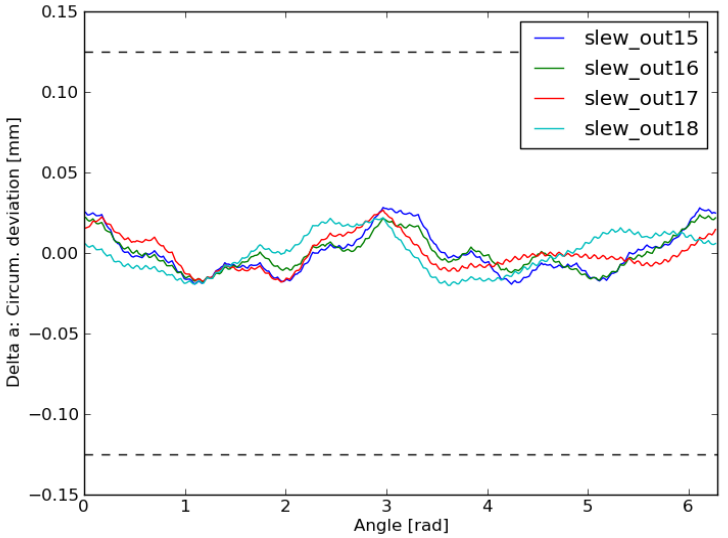
Lcomb 15: No OOB

Lcomb 16: OOB x-direction

Lcomb 17: OOB y-direction

Lcomb 18: OOB xy-direction





Slew ring distortion

Installation tolerances:

Circumferential flatness

$\Delta a \leq 0.25\text{mm}$

Inclination on radial plane

$\Delta b \leq 0.125$ mm

(measured over 100 mm)

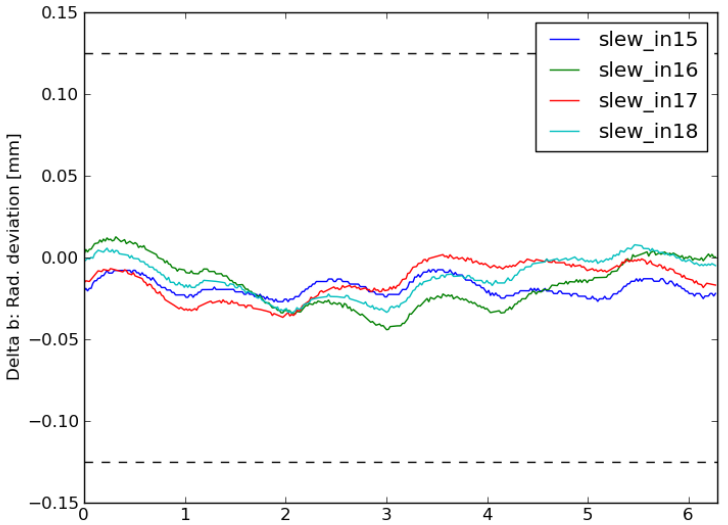
Graphs corrected for rigid body translation & rotation

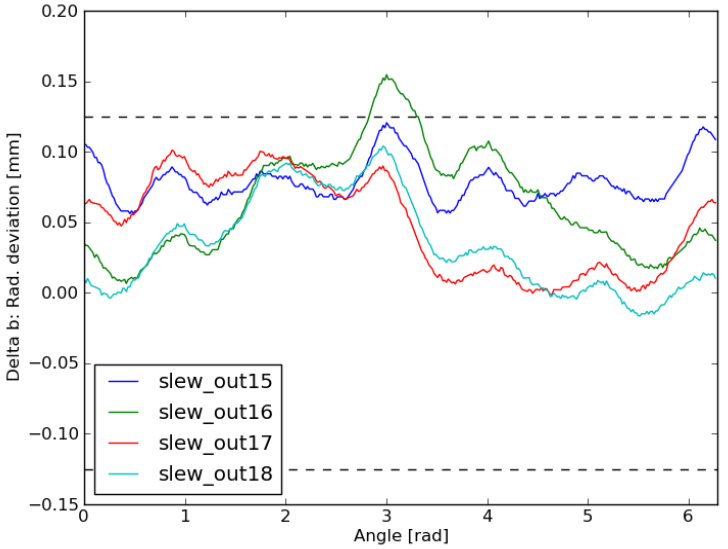
Lcomb 15: No OOB

Lcomb 16: OOB x-direction

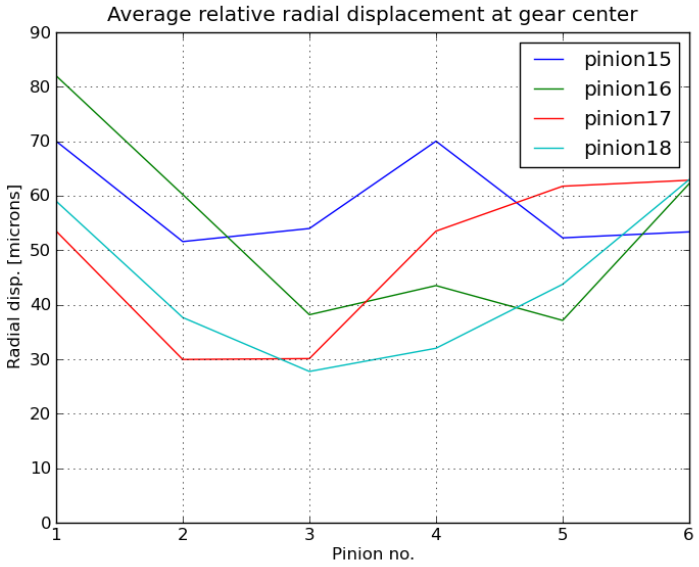
Lcomb 17: OOB y-direction

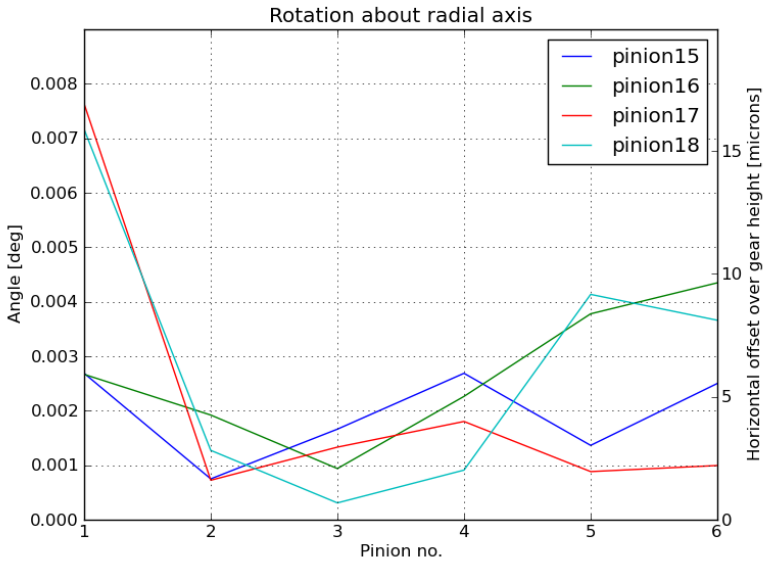
Lcomb 18: OOB xy-direction

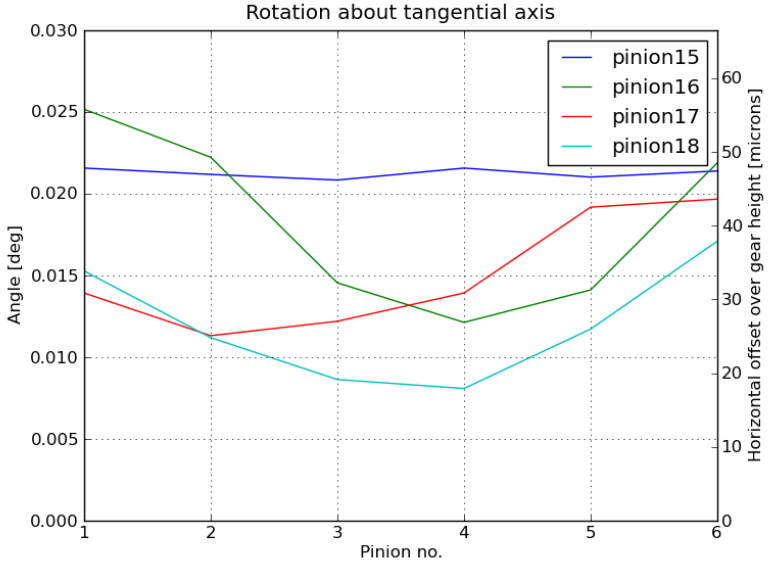




Ring gear – pinion misalignment



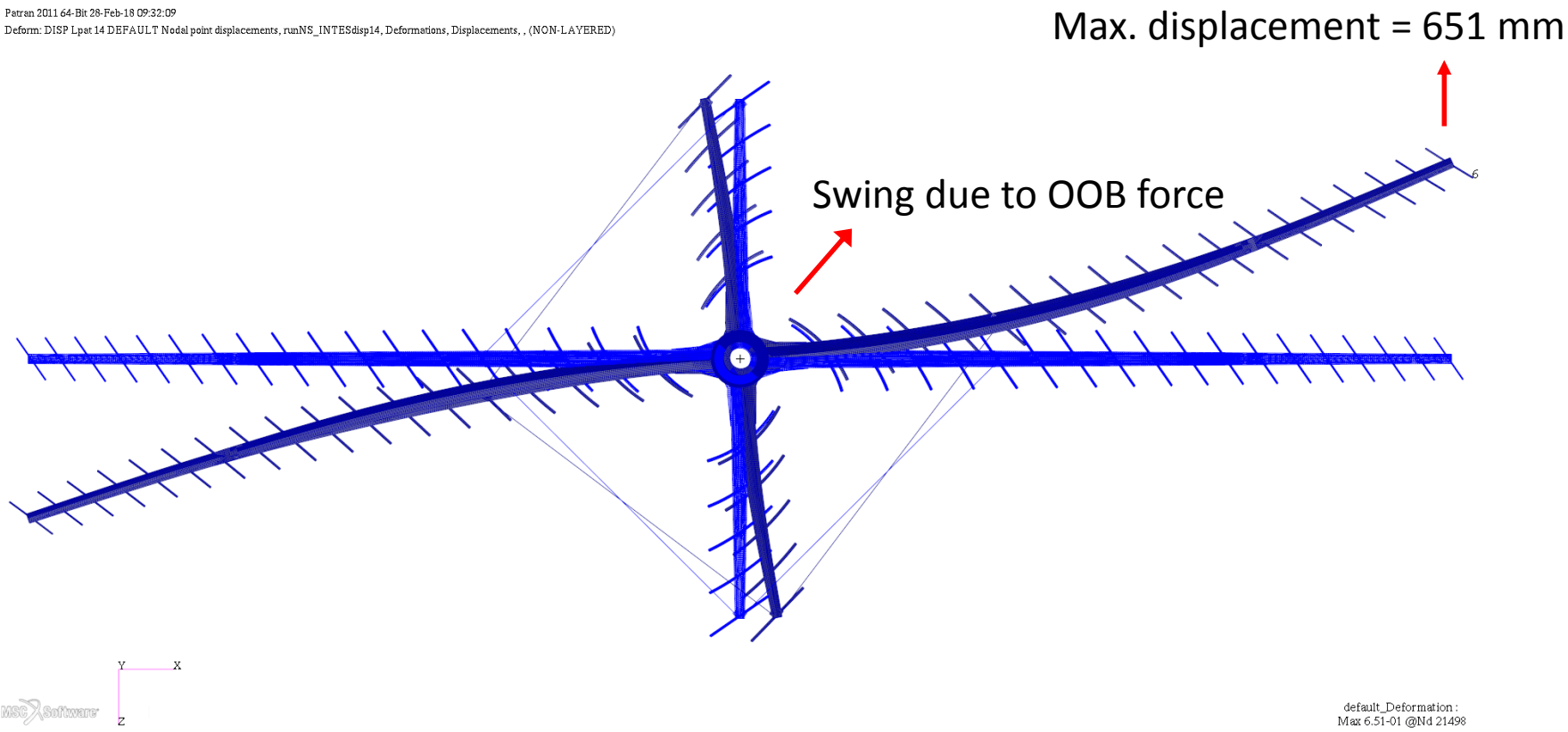




Possible misalignment includes 1 translational and 2 rotational components:

- Radial displacement
- Rotation about radial axis
- Rotation about tangential axis

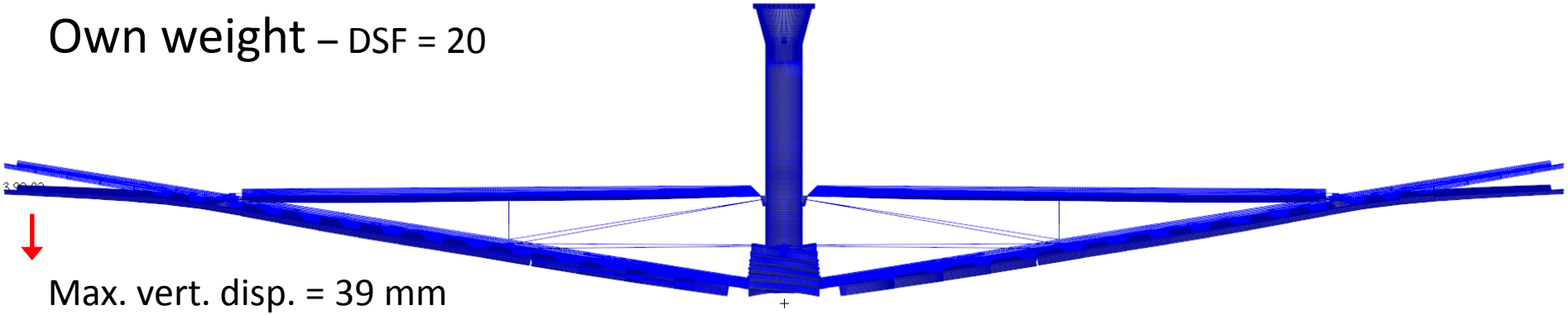
Rake deformation



Operational loading conditions – Deformation Scale Factor = 10

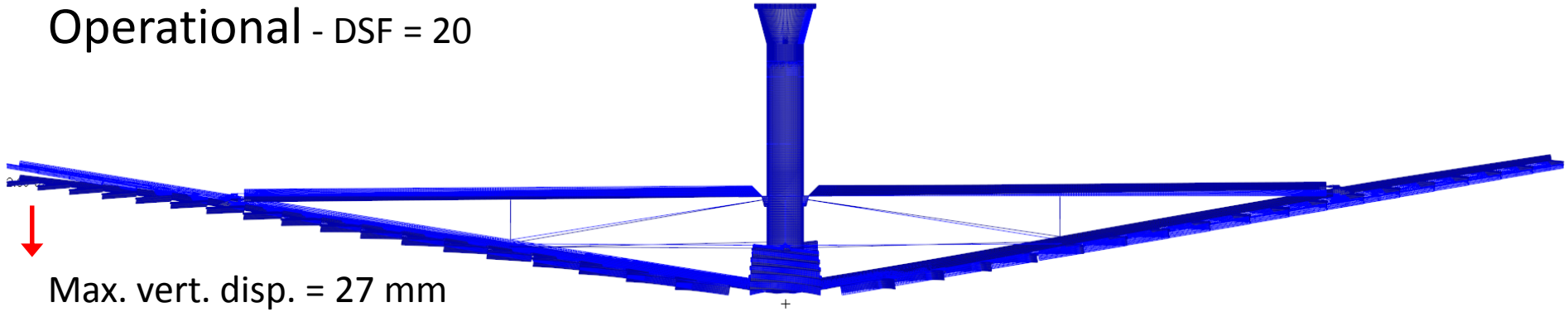
Rake vertical deflections

Own weight – DSF = 20



Max. vert. disp. = 39 mm

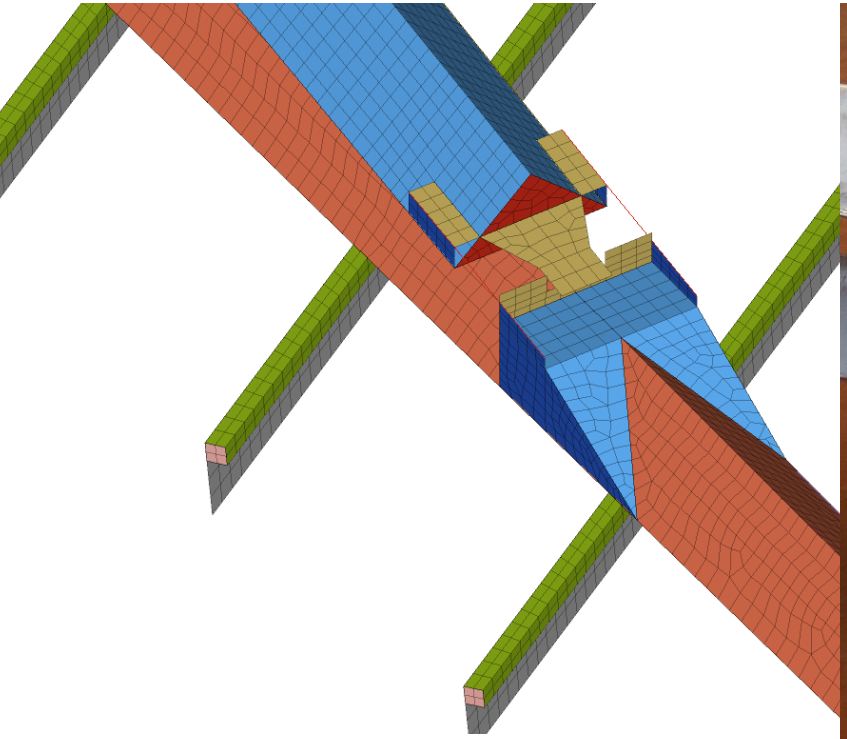
Operational - DSF = 20



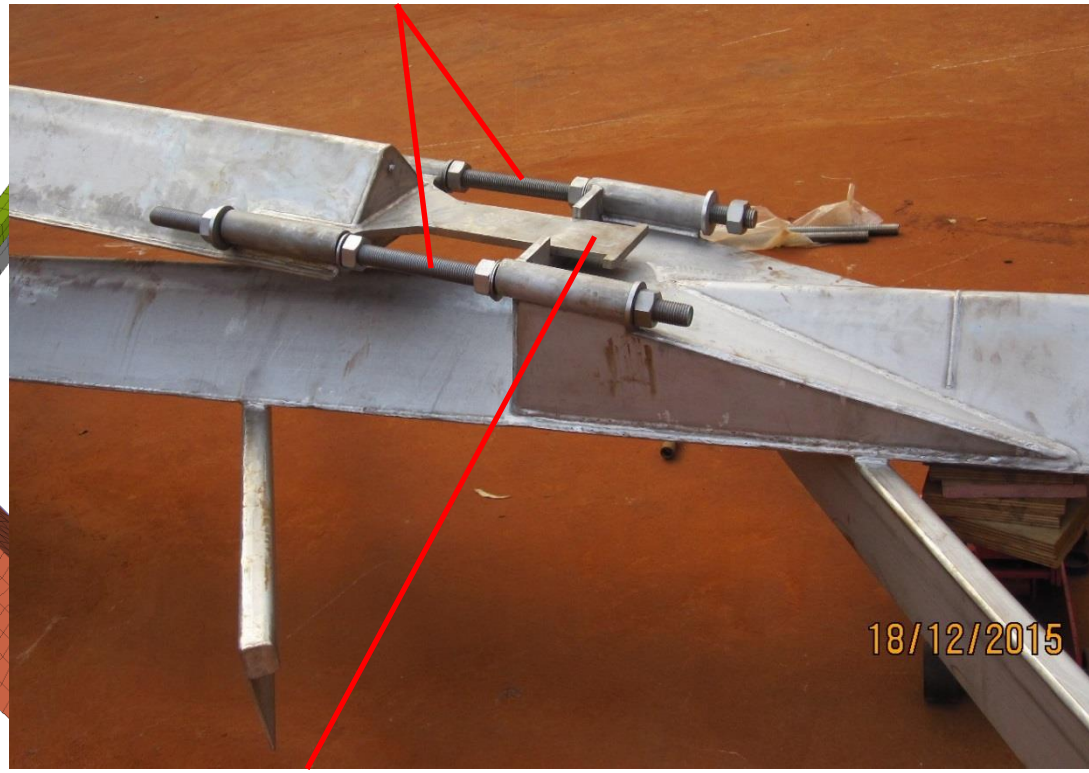
Max. vert. disp. = 27 mm

Rake design features: Vertical adjustment

Vertical adjustment of rake arms are required to ensure that the bottom edges of the scraper blades on both long rake arms trace the same floor cone.
If this is not achieved, unacceptable out-of-balance loads will result.

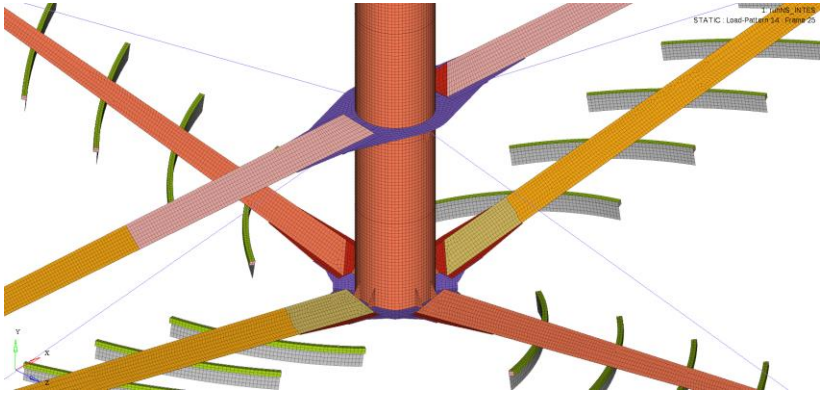


M36 tie-rods for vertical adjustment

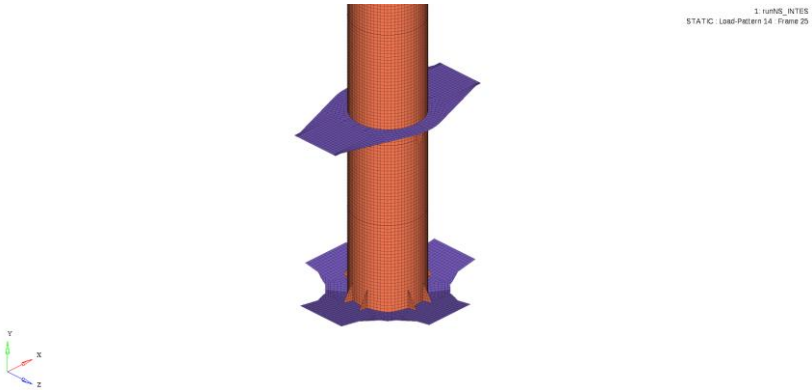


Horizontal plate in yoke for torque transfer

Rake design features: Hinged connection to torque tube



Hinged connection of rake and towing arms: Horizontal plates to transfer torque without having bending stiffness



Rake and towing arms removed for clarity

After all is said and done

Thank you